

SB750
AIE891
1980

BACKGROUND FOR WEED MANAGEMENT PROGRAM

PHASE I FINAL REPORT

Evaluation of Forest Pest Management Programs

Contract No. FS-53-3187-9-30

JANUARY, 1980



FOR:
U.S.D.A. Forest Service
Policy Analysis Staff
Washington D.C.



BY:



Center for Natural Areas
South Gardiner, ME; Washington, D.C.; Los Angeles, CA

LIBRARY

MAY 7 1981

ROCKY MOUNTAIN

STATION

58761
AIE 89
1980

PREFACE

This report was prepared by the Center for Natural Areas, under contract to the USDA-Forest Service. The Center for Natural Areas (CNA) is a non-profit resource management firm formerly associated with the Smithsonian Institution. The Center employs a multi-disciplinary staff including policy analysts, economists, sociologists, and biologists. Project staff is augmented by consultants with expertise in forestry, the use of herbicides, forest ecology, and other aspects of weed management.

The purpose of this study is to evaluate thoroughly the USDA-Forest Service's pest management activities by examining pest management policy, the effectiveness of present programs, and by describing options for program adjustments where appropriate. The study is national in scope and examines the three Deputy Areas which are involved in pest management activities: National Forest System, State and Private Forestry, and Research.

This report concludes Phase I of the study. The report provides a basic descriptive account of Forest Service weed management programs. The results of this report were used to develop issues and choose case studies for further analysis in Phases II and III. Conclusions stated herein are preliminary and presented for the purpose of summary. Similarly, alternative techniques mentioned are only descriptive accounts of published feelings toward techniques, not discussion of recommended methods. Unfortunately, during the course of the study we found that, in many instances strong, existing opinions have not been documented in the scientific literature. A companion report summarizes USDA-Forest Service insect/disease management programs. Both weed and insect/disease management reports will include an economic perspective of Forest Service pest management as an addendum.

When this report was being prepared, the pesticide-use chapter of the Forest Service Manual was being revised and renumbered from Chapter 2140 to Chapter 2150. Simultaneously, a new chapter on integrated pest management was being developed and reviewed. These draft manual revisions have recently been approved and included in the Manual. Thus, references to Sections 2140 (pesticide use) should be to Section 2150 and draft 2140 (integrated pest management) is no longer a draft.

CNA staff wish to acknowledge the assistance provided by the USDA-Forest Service at all levels. Forest Service direction and coordination has been provided by the Policy Analysis staff of the Programs and Legislation Deputy Area. Line and staff officers were extremely helpful at both the field and national levels. We wish especially to acknowledge assistance from the staffs of

Timber Management, Range Management, Forest Insect and Disease Management, Watershed Management, Fire Management, Wildlife Management, Timber Management Research, and Forest Environment Research.

Copies of this report are available from Policy Analysis in the Washington Office of the Forest Service.

PARTICIPANTS

CNA Staff:

David Cottingham, M.E.M.
F. Dominic Dottavio, Ph.D.
Malcolm Hunter, Ph.D.
James R. Hynson, M.S.
Brian O'Sullivan, M.S.
Kermit Rader, J.D.
Wesley Scholz, J.D.
David Tilles, Ph.D.
Alfred Zangri, M.A.

Consultants:

Dr. Burton V. Barnes, University of Michigan, Ann Arbor
Dr. Dean Gjerstad, Auburn University, Auburn, Alabama
Dr. Harvey Holt, Purdue University, West Lafayette, Indiana
Dr. Michael Newton, Oregon State University, Corvallis
Mr. Robert Pearl, USDA-Forest Service, Retired

Support assistance provided by:

Carmen Belanger, Word Processing
Glenn Hazelton, Graphics
Kathleen Palmer, Word Processing
Priscilla Slack, Word Processing

TABLE OF CONTENTS

	<u>page</u>
Preface	i
Participants	iii
Table of Contents	iv
List of Tables	v
List of Figures	viii
Abbreviations	ix
Introduction	x
1.0 Laws	1-1
2.0 Policies	2-1
3.0 Organization and Administration	3-1
4.0 Weed Management and Research on Commercial Forest Lands	4-1
5.0 Weed Management and Research on Rangelands	5-1
6.0 Weed Management and Research on Rights-of-Way and Fuelbreaks	6-1
7.0 Developments in Environmental Analysis of Weed Management Activities	7-1
8.0 Weed Management Issues	8-1
9.0 Literature Cited	9-1
Appendix	A-1

LIST OF TABLES

		<u>Page</u>
I-1	National Forest weed management, FY 1978 activities	ix
1-1	Summary of major laws affecting weed management	1-2
1-2	Litigation involving the use of herbicides on National Forest System Lands	1-9
3-1	Delegation of authority for weed management	3-8
3-2	Inter-and intra departmental committees	3-10
4-1	Site preparation for planting, seeding, and natural regeneration	4-3
4-2	Site preparation methods research through experi- ment stations	4-5
4-3	Estimated proportion of use of weed management methods for site preparation and rehabilitation by section	4-7
4-4	Site preparation by fire, as a percentage of total site preparation	4-9
4-5	Annual reforestation and timber stand improvement. Release and weeding	4-14
4-6	Release methods research through experiment stations	4-17
4-7	USDA-Forest Service use of herbicides in FY 76	4-17
4-8	Estimated proportion of use of weed management methods for release and TSI by section	4-20
4-9	Burning to control understory vegetation (acres)	4-22
4-10	Annual reforestation and timber stand improvement. Precommercial thinning (acres)	4-27
4-11	Thinning methods research at experiment stations	4-29
5-1	Indices of range grazing in the contiguous states in 1976 by Region, with projections of demand to 2030	5-2
5-2	Acres of accomplished brush management in the National Forest System by Region	5-3
5-3	Regional USDA-Forest Service use of various methods of range brush management, in acres, for 1978	5-7
5-4	Number of research reports listed in Forest Service annual research accomplishments which address various methods of range brush management, with comparisons between experiment stations	5-9
5-5	Number of Forest Service research reports which address the topic of improving grazing systems	5-16
5-6	Acres of accomplished range plant control in the National Forest System, by Region	5-18
5-7	Mean percent of range plant control accomplishments by method for Forest Service Regions	5-20

LIST OF TABLES (continued)

	<u>Page</u>
5-8 Acres accomplished by the USDA-Forest Service under the noxious farm weeds program	5-21
5-9 Mean percent of noxious farm weeds control accomplishments by method for Forest Service Regions	5-22
6-1 Comparison of vegetation management methods for rights-of-way	6-3
6-2 Useage patterns of chemical methods on rights-of-way	6-5
7-1 USDA-Forest Service and Federally funded university research on the environmental effects of weed management	7-2
7-2 Number of Forest Service research reports which address the subject of environmental effects caused by herbicides	7-4
A-1 Summary of softwood timber demands on and supplies from forests in the contiguous States by timber supply region 1952, 1962, 1970, and 1976 with projections to 2030 under alternative price assumptions	A-1
A-2 Average net annual and potential growth per acre in the United States, by ownership, and section, 1976	A-2
A-3 Number of Forest Service research reports on the use of herbicides as one method of site preparation	A-3
A-4 Properties of herbicides used in forestry	A-4
A-5 Number of Forest Service research reports on prescribed fire as one method for site preparation	A-8
A-6 Number of Forest Service research reports on mechanical treatment as one method for site preparation	A-9
A-7 Number of Forest Service research reports on the use of herbicides for release	A-10
A-8 Number of Forest Service research reports on the use of prescribed fire for release	A-11
A-9 Number of Forest Service research reports on the use of individual stem treatment of herbicides for thinning	A-12
A-10 Number of Forest Service research reports on the use of mechanical treatments for thinning	A-13
A-11 Induced progression by manipulation of factors in range ecosystems	A-14
A-12 Condition of rangeland ecosystems in the United States, 1976	A-15
A-13 Percent and number of acres of range brush management accomplished with prescribed fire	A-17
A-14 Number of Forest Service research reports on the use of fire as a method for weed management on rangelands	A-18
A-15 Number of species of range brush for which various herbicides are recommended	A-19
A-16 Herbicides used on range considering method of application, selectivity, and type of action	A-20

LIST OF TABLES (continued)

	<u>Page</u>
A-17 Percent and number of acres of range brush management accomplished with chemical herbicides using broadcast methods	A-21
A-18 Percent and number of acres of range brush management accomplished with chemical herbicides applied using selective methods	A-22
A-19 Number of Forest Service research reports on the use of herbicides applied using broadcast methods, as a treatment for weed management on rangelands	A-23
A-20 Comparison of mechanical equipment used in seedbed preparation on rangeland	A-24
A-21 Percent and number of acres of range brush management accomplished with mechanical methods	A-26
A-22 Number of Forest Service research reports on mechanical methods as treatment for weed management on rangelands	A-27
A-23 Percent and number of acres of range brush management accomplished with seeding	A-28
A-24 Number of Forest Service research reports on seeding as a treatment for weed management on rangelands	A-29
A-25 Rights-of-way (ROW) acreage by type and region in the United States	A-30

LIST OF FIGURES

	<u>Page</u>
I-1 Administrative regions and experiment stations of the USDA-Forest Service	xii
2-1 The NEPA Process	2-15
3-1 Roles and Line-Staff Relationships	3-2
3-2 Weed management organization	3-4
3-3 USDA NAPIAP/RPAR Organization	3-13
4-1 Annual site preparation methodology research	4-4
4-2 Annual release method research	4-19
4-3 Annual thinning methods research	4-30
5-1 Methods of range brush management accomplishments	5-6
5-2 Annual comparisons of number of research reports listed in Forest Service annual research accomplishments which address various methods of range brush management	5-8

ABBREVIATIONS USED IN TEXT

EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ES	Environmental Statement
FEPCA	Federal Environmental Pesticide Control Act
FER	Forest Environment Research
FI&DM	Forest Insect and Disease Management
FI&DR	Forest Insect and Disease Research
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FPL	Forest Products Laboratory
FS	Forest Service
FSM	Forest Service Manual
INT	Intermountain Forest and Range Experiment Station
IPM	Integrated Pest Management
IPMWG	Integrated Pest Management Working Group
NA	Northeastern Area
NAPIAP	National Agricultural Pesticide Impact Assessment Program
NC	North Central Forest Experiment Station
NE	Northeastern Forest Experiment Station
NEPA	National Environmental Policy Act of 1969
NFMA	National Forest Management Act of 1976
NFS	National Forest System
OEQ	Office of Environmental Quality, Department of Agriculture
P&L	Programs and Legislation
PNW	Pacific Northwest Forest and Range Experiment Station
PSW	Pacific Southwest Forest and Range Experiment Station
RM	Rocky Mountain Forest and Range Experiment Station
ROW	Right-of-way
RPA	Forest and Rangeland Renewable Resources Planning Act of 1974
RPAR	Rebuttable Presumption Against Registration
SA	Southeastern Area
SE	Southeastern Forest Experiment Station
SO	Southern Forest Experiment Station
S&PF	State and Private Forestry
TAG	Technical Advisory Group
TMR	Timber Management Research
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
WO	Washington Office (of the Forest Service)

INTRODUCTION

A weed can be defined as any plant that is useless, troublesome, or injurious to any resource being managed on a given area of land. As such, the identification of what is and is not a weed depends not only on the characteristics of that plant or plant species, but, to a great extent, on the management objectives for the land being considered. For example, on a site considered as commercial forest, woody shrubs which compete for light, moisture, and nutrients with desirable crop trees are considered useless and troublesome; therefore, they are weeds. However, if the commercially desirable "crop tree" is within a powerline right-of-way, it could be classed as a weed because it is injurious to the management objectives of the right-of-way. Since the existence of woody shrubs in the right-of-way would make it more difficult for trees to invade, shrub species in this instance would be considered as the beneficial vegetation rather than the weeds.

The management objective element in the definition of weed often precludes the identification of weeds as such on the basis of species. For example, where timber production is the major management objective, and natural regeneration is the mechanism for reforestation, too many trees of the crop species may successfully establish themselves. Since only a limited supply of moisture, light, and nutrients exists on the stand, the growth of more than the optimum number of trees is injurious to the timber resource being managed, and the excess crop trees are therefore weeds.

As a result, any management practice which manipulates vegetation to increase the output of a particular resource(s) can be identified as weed management. This is the definition of weed management used throughout the remainder of this report. Under this definition, most of the staff groups in the National Forest System branch of the USDA-Forest Service actively participate in weed management (Table I-1). In addition, USDA-Forest Service research seeks to develop and assess technologies which will more effectively manipulate vegetation to accomplish management objectives.

This report summarizes and describes the activities of the USDA-Forest Service in weed management from several different perspectives. The first chapter summarizes all laws relevant to USDA-Forest Service weed management activities, including mandates for management of the National Forest System, directives for research activities, pesticide regulation, and environmental constraints. Chapter 2.0 addresses agency, departmental, and executive policies regarding weed management as stated in the Forest Service Manual, and other direction-giving documents. The third chapter describes the roles of the offices and staff groups in the USDA-Forest

TABLE I-1. National Forest weed management, FY 1978 activities (Source: Staff Group Accomplishment Reports unless otherwise noted).¹

STAFF GROUP	ACTIVITY	ACRES ACCOMPLISHED
Timber Management	Site preparation	246,059
	Release and Weeding	110,729
	Precommercial thinning	310,243
	Prescribed burning to control understory vegetation	50,688
	TOTAL	717,699
Range Management	Cover Manipulation (Woody vegetation)	68,613.9
	Range Plant Control (Herbaceous vegetation)	9,011.8
	Noxious Farm Weeds	18,542.6
	TOTAL	96,168.3
Lands/Engineering	Special Use Permits, ROW Management	6,762 ²
Fire Management	Fuelbreaks	1,580 ²
Wildlife Management	Wildlife Habitat Improvement	837,000 ³
Recreation		---
Watershed Management	Soil and Water Resource Improvement	88,000 ³

¹Data re Lands, Engineering, Fire Management, Wildlife Management, and Watershed Management staff groups not as precise as that obtained for Timber Management and Range Management.

²Acreage only includes that accomplished through the use of herbicides. Data from national pesticide use report, Forest Service accomplishment report, FY 1978.

³Total accomplishments for that staff group, including non "weed management" activities, and possibly areas where "technical advice" was provided to other staff groups.

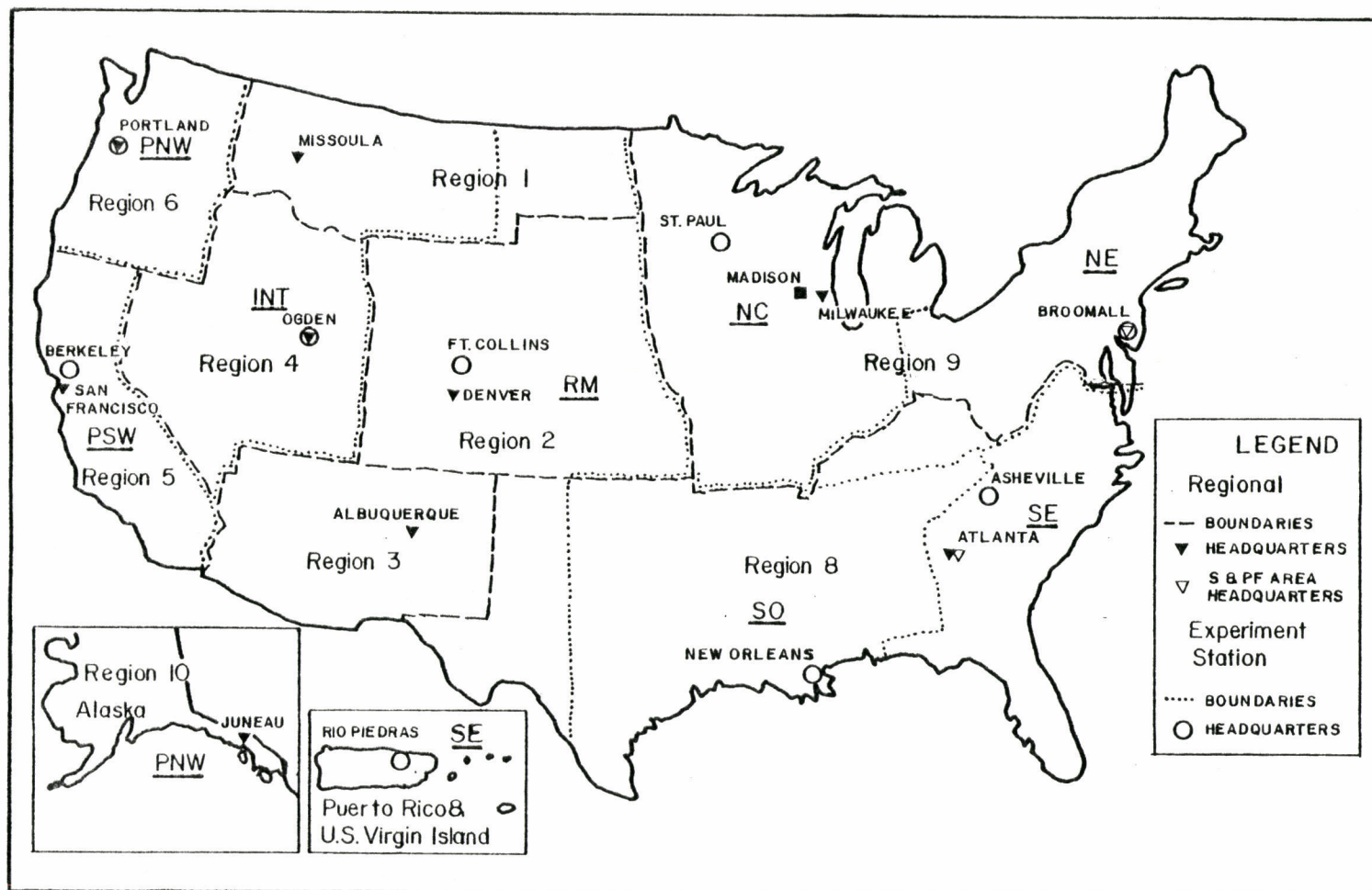


FIGURE I-1. Administrative regions and experiment stations of the U. S. Forest Service.
(Source: USDA-Forest Service 1979 Organizational Directory)

Service as they pertain to weed management.

Chapters 4.0, 5.0, and 6.0 describe the "on-the-ground" weed management activities of the USDA-Forest Service for timber (Chapter 4.0), range (Chapter 5.0), rights-of-way, and fuelbreaks (Chapter 6.0). These chapters also describe alternative methods of management and present data documenting the relative level of emphasis (in acreage accomplished where available) over time in each weed management activity. Unless otherwise noted, these data are broken down by Region, using Forest Service Regional and Experiment Station boundaries (Figure I-1). The activities described account for the majority of the Forest Service weed management activities. This is supported by data from Witt (1978), which indicate that the activities presented in these chapters accounted for 95.4 percent of USDA-Forest Service herbicide use in 1976.

Chapter 7.0 briefly summarizes the activities of research to document the environmental effects of weed management activities, and presents a brief description of the current herbicide controversy in which the Forest Service is involved. Chapter 8.0 lists and describes issues identified in the course of preparing this report. The issues will be used in the succeeding phases of this study (II and III) to refine our case study approach to evaluating Forest Service pest management programs, and to develop alternative management strategies for consideration in revising the programs.

1.0 LAWS

The laws applicable to weed management are broken down into two areas; National Forest Management legislation and environmental constraints.

The laws which authorize USDA-Forest Service activities refer to the control of undesirable vegetation as an integral and necessary aspect of forest and range management, rather than as an autonomous activity. They recognize that weed management is a necessary procedure to improve timber and forage productivity, eradicate noxious weeds, and other similar activities, but do so through control of all management activities on National Forest System lands and only peripherally relate to weeds (see Table 1-1).

In addition to National Forest management legislation, several environmental laws directly affect weed management activities, especially those activities which use herbicides. Environmental assessments and impact statements, herbicide registration, and clean air standards play significant roles in planning, implementing, and evaluating weed management activities.

1.1 The Forest and Rangeland Renewable Resources Planning Act as Amended by the National Forest Management Act

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) (16 U.S.C. 1600-1614) as amended by the National Forest Management Act of 1976 (NFMA) requires the USDA-Forest Service to prepare assessments and inventories of the renewable natural resources on National Forest lands. The inventories and assessments are to be used to establish a land and resource management program which delineates the goals and long-range plans for the National Forests. An evaluation of alternative resource management plans is to be conducted as part of the planning process. NFMA also requires the Secretary of Agriculture to submit an "annual report to Congress on the amounts, types, and uses of herbicides and pesticides used in the National Forest System, including the beneficial or adverse effects of such uses" (16 U.S.C. 1601(e)).

RPA/NFMA sections 4 and 6 are essential to the topic of weed management. Section 4(d) of the NFMA covers "cut-over or otherwise denuded or deforested" National Forests that have not been reforested (backlog areas) or which are growing at less than their potential. This section requires the USDA-Forest Service to prepare an inventory of such lands and a schedule of action eliminating the backlog by 1984. Treatment of lands in need of reforestation includes preparing sites, thinning stands, and removing "deleterious growth and underbrush" (16 U.S.C. 1601(d)).

TABLE 1-1. Summary of major laws affecting weed management.

A. Forest and Rangeland Renewable Resources Planning Act (1974)	1. Initiated the RPA planning and assessment process.
B. National Forest Management Act (1976)	1. Amended the RPA. 2. Established guidelines for National Forest System planning and management.
C. Federal Insecticide, Fungicide and Rodenticide Act (1947)	1. Established registration and labeling requirements for pesticides.
D. Federal Environmental Pesticide Control Act (1972)	1. Amended FIFRA. 2. Established criteria of no "adverse environmental effects" for registration of pesticides. 3. Led to the establishment of RPAR.
E. National Environmental Policy Act (1969)	1. Requires Federal agencies to prepare environmental impact statements on actions significantly affecting the environment.
F. Clean Air Act Amendments (1977)	1. Established Class I air quality areas where visibility cannot be impaired.
G. Carlson Act (1968)	1. Established noxious farm weed control program. 2. Established cooperative agreement between Federal-State-private landowners for control of noxious farm weeds.
H. Forest and Rangeland Renewable Resources Research Act (1978)	1. Amended and repealed the McSweeney-McNary Act of 1928 which had been the authorizing legislation for forest and range research. 2. Authorizes research on renewable natural resource management, utilization, protection, and assessment.

The USDA-Forest Service evaluation and action plans were prepared in May and July 1978, respectively.

RPA/NFMA Section 6 (16 U.S.C. 1604) establishes criteria for the development of USDA-Forest Service land and resource management plans for the National Forest System. The regulations promulgated under this section require that plans be developed to "guide all natural resource management activities and establish management standards and guidelines for the National Forest System" (36 C.F.R. 219.1(b)). Management concerns which "should be considered" include producing timber and managing and improving range resources and grazing (36 C.F.R. 219.10(b)). Pest management activities are included as an aspect of the Forest and Regional plans in the context of "disease, pests, and similar threats" (36 C.F.R. 219.10(b)(5)), which indicates that the regulatory definition of "pest" may not include weeds or plants. ("Pest" is not defined in Section 219.3 - Definitions.)

All management practices must:

"1) prevent or reduce serious, long-lasting hazards from pest organisms under the principles of integrated pest management; and

"2) be monitored and evaluated...to assure that practices protect soil, watershed, fish, wildlife, recreation, and aesthetic values; maintain vegetative productivity; and reduce hazards from insects, disease, weed species, and fire" (36 C.F.R. 219.13(b)(3) and (5)).

It is again unclear as to the interpretation of "pest organisms" in item 3, but it is evident that item 5 includes plants as pests which should be monitored and evaluated. Thus, even though the regulations do not establish weed management as an autonomous planning activity, timber, range, and right-of-way plans have to address weed problems in order to be comprehensive.

1.2 Federal Insecticide, Fungicide and Rodenticide Act as Amended by the Federal Environmental Pesticide Control Act

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended by the Federal Environmental Pest Control Act of 1972 (FEPCA) (7 U.S.C. 135-136) delegates the major responsibility for regulating chemical pesticides, including herbicides, to the Environmental Protection Agency (EPA). Some of these responsibilities include the formulation of standards, the registration, suspension, and cancellation of materials, the granting of exemptions, the review of labels, and the certification and licensing of applicators. All USDA-Forest Service herbicide activities for

weed management must be conducted in compliance with FIFRA. This section briefly summarizes the requirements and procedures of the Acts and then discusses in more detail those aspects of the Acts which have proven to be of particular relevance to USDA-Forest Service herbicide-use programs.

The central provision of FIFRA is the requirement that all "economic poisons" must be registered with EPA before they may be distributed, sold, or offered for sale (7 U.S.C. 135a). Economic poisons are defined as:

"any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, weeds and other forms of plant life or animal life...which the Administrator shall declare to be a pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant or dessicant" (7 U.S.C. 135 (a)) (emphasis added).

FIFRA goes into considerable detail concerning registration procedures, the criteria for approval, and the consequences of disapproval (7 U.S.C. 136). A registered pesticide may be classified for general use, restricted use, or both (7 U.S.C. 136a(d)). A restricted use pesticide, i.e., one which is considered to have a high potential for personal or environmental risk, can be applied only under the supervision of a certified applicator or subject to other restrictions. Several major exemptions to the registration requirements are provided including: 1) pesticide use pursuant to an experimental use permit; 2) use by state or Federal agencies after the Administrator determines that emergency conditions exist; or 3) use to meet special local needs even though criteria for Federal registration are not met (7 U.S.C. 136).

The strong interest of USDA, which had regulated pesticides prior to EPA's establishment in 1970, was recognized by the law's drafters. Several proposals which would have required the concurrence of the Secretary of USDA on decisions made by EPA (regarding pesticide registration, classification, and cancellation as well as proposed and final regulations) were rejected by Congress (H. R. Report 94-497, 94th Cong., 1st Sess., 33 (1975)). Instead, an elaborate consultation mechanism was built into these decision-making processes.

At least 60 days prior to signing a proposed regulation and 30 days prior to signing a final regulation, the Administrator of EPA must provide the Secretary of USDA with a copy (7 U.S.C. 136w(a)(1)). Timely comments by the Secretary and the responses of the Administrator must be published in the Federal Register along with the text of the regulations. Similarly, the Adminis-

trator must provide the Secretary with a copy of any notice of intent to cancel the registration of a pesticide and an analysis of the impact of the proposed action on the agricultural economy at least 60 days prior to sending such notice to the registrant or making it public. The comments by the Secretary and the responses of the Administrator must also be published in the Federal Register.

Further cooperative arrangements between USDA and EPA are specified in two memoranda of understanding between the two agencies (Memorandum of Understanding between USDA and EPA, December 2, 1976 and October 1977). These procedures are discussed in section 3.3 of this report.

The Senate Commerce Committee, which held hearings on the Act, felt that it was important to require EPA to make a full weighing of competing interests in making its determinations. Thus, the Committee required the applicant to prove that the use of the chemical for the specified purposes and by the specified methods is safe and poses no "unreasonable adverse effects" on the environment. This process includes consideration of the economic, social, and environmental costs and benefits of the pesticide. It is intended that "any adverse effect ought not to be tolerated unless there are overriding benefits from the use of a pesticide" (Senate Report 92-970, 92nd Cong., 2nd Sess., 11(1972)).

Basic criteria governing registration apply also to cancellation proceedings. The Administrator may issue a notice of intent to cancel the registration of a pesticide, or change its classification if it appears that the pesticide "when used in accordance with widespread and commonly recognized practice generally causes unreasonable adverse effects on the environment" (7 U.S.C. 136d(b)). Thus, the key determination is, once again, whether continued use may lead to "unreasonable adverse effects on the environment."

Another option open to the Administrator to deal with suspect pesticides is suspension. If the Administrator determines "that action is necessary to prevent an imminent hazard during the time required for cancellation or change in classification proceedings, sale and use of the pesticide may be immediately suspended" (7 U.S.C. 136d(c)(1)). EPA exercised this option to suspend the use of 2,4,5-T and Silvex on forests, rights-of-way, and pastures (44 Fed. Reg. 15874 March 15, 1979). The term "imminent hazard" is defined by FIFRA to mean "a situation which exists when the continued use of a pesticide would be likely to result in unreasonable adverse effects on the environment or will involve hazard to the survival of a species declared endangered or threatened pursuant to the Endangered Species Act" (7 U.S.C. 136(1)). Court cases have interpreted the most important element of "imminent

hazard" to be a "serious threat to public health" (Environmental Defense Fund, Inc. v. Ruckelshaus, 439 F. 2d 584, 597 (D.C. Cir. 1971)). A hazard may be "imminent" even though its impact may not be apparent for many years and even though the threat is to fish and wildlife and not directly to people.

1.3 National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321, 4331-4335, 4341-4347) affects USDA-Forest Service weed management activities by requiring that environmental impact statements (EIS's) be prepared for "major Federal actions significantly affecting the quality of the human environment" (42 U.S.C. 4332(c)). NEPA's requirement for EIS's has allowed citizens' groups to enjoin weed management activities, especially when herbicides are being used, based on the premise that the statements are inadequate in their weighing of relevant scientific evidence or their consideration of alternatives.

USDA-Forest Service activities are reviewed for their environmental impact through the "NEPA process" as described in Section 1950 of the Forest Service Manual (FSM) (see Section 2.12 of this report).

1.4 Clean Air Act

The Clean Air Act, as amended by the 1977 amendments (42 U.S.C. 7401 et seq.), indirectly affects some weed management projects where prescribed fire is to be used. Class I air quality areas are National Parks, Wilderness Areas, and National Monuments where air quality is high and which are given special protection in the Clean Air Act Amendments (42 U.S.C. 7470). In these areas, visibility cannot be impaired. Fires, whether prescribed for forest and rangeland management or naturally occurring, produce smoke which impairs visibility. Thus, in areas that have been classified Class I or areas that adjoin lands of such designation, this Act constrains the use of prescribed fire as a weed management tool.

1.5 Carlson Act

The Carlson Act of 1968 (43 U.S.C. 1241) establishes the noxious farm weed control program as a cooperative venture between Federal, state, and private landowners. The Act authorizes the USDA-Forest Service to eradicate noxious farm weeds, which are defined as noxious by the states, on National Forest lands and to work with state and local agencies to do the same on private land. When compared to the other weed management activities of the USDA-Forest Service, the noxious farm weed control program is relatively minor in scope.

1.6 Forest and Rangeland Renewable Resources Research Act

The Forest and Rangeland Renewable Resources Research Act of 1978 (16 U.S.C. 1600, 1641-1647) authorizes the Secretary of Agriculture to conduct and support research activities which complement the policies and guidelines of the RPA/NFMA. Research is to be conducted on renewable resource management, protection, and utilization, as well as on environmental effects of resource management. Weed management and control is directly applicable to two of these general areas:

1) Renewable resource management research includes investigations on: "managing, reproducing, planting, and growing vegetation on forests and rangelands for timber, forage, water, fish and wildlife, esthetics, recreation, (and) wilderness; and developing alternatives for the management of forests and rangelands."

2) Renewable resource protection includes activities "related to protecting vegetation and other forest and rangeland resources...from fires, insects, diseases, noxious plants, animals, and air pollutants, and other agents through biological, chemical, and mechanical control methods and systems..." (16 U.S.C. 1642).

Manual techniques are not specifically mentioned as methods on which research should be conducted. Research efforts to control weeds have not emphasized manual methods. However, opponents of herbicides often cite manual brush control as a viable alternative to chemical methods.

Special emphasis in the Act is placed on the need for increasing research cooperation and coordination of Federal and state agencies' activities with those of universities and private interests. This is accomplished through competitive research grants made to institutions and individuals.

The Act repeals the McSweeney-McNary Act of 1928, which was the basic authorizing legislation for USDA-Forest Service and U. S. Department of Agriculture (USDA) research, all of which deals with renewable natural resources.

Recent controversies over various forest management activities, particularly the use of herbicides like 2,4,5-T and 2,4-D, have been raised because of questions about the impact of these chemicals on local citizens' health. A question that is frequently raised on this subject is how much and what type of research the USDA-Forest Service should be doing on the health effects of its programs. The Forest and Rangeland Renewable Resources Research Act does not address human health or include it in the discussion of environmental research. Therefore it neither authorizes nor restricts the USDA-Forest Service from conducting such research.

1.7 Major Court Cases

Legal challenges to USDA-Forest Service weed management programs have focused on herbicide use and relied primarily on one of two arguments: 1) the Environmental Impact Statements (EIS's) prepared concerning proposed herbicide use operations are inadequate in their weighing of a) relevant scientific evidence or b) their consideration of alternatives to the proposed action; or 2) the implementation of the proposed action will lead to significant, irreparable harm to private property, public lands and resources, or public health. In most of the cases, the relief sought is the issuance of an injunction barring the completion of the proposed action. Decisions challenging the latter of the arguments are based on the circumstance of individual cases and it is, therefore, rarely beneficial to draw general conclusions from these cases. On the other hand, the Federal courts have developed a whole body of law concerning the adequacy of EIS's prepared on herbicide programs. The basic principles which are established by the case law will be outlined in this section.

Few cases directly related to USDA-Forest Service herbicide use have reached the Federal Circuit Courts and as a result, few such cases have been reported. The Center for Natural Areas has been in contact with the USDA Office of General Counsel, Natural Resources Division, and received information on eight unreported District Court decisions. In three of these cases, the application of herbicides was enjoined until compliance with NEPA was found, whereupon the injunction was lifted and the USDA-Forest Service was allowed to proceed (Table 1-2). These cases do not develop any significant new principles of law. Rather, they reflect the application of established principles to varying factual circumstances with regard to environmental impact statements.

Perhaps the fundamental principle which can be derived from the relevant case law is that the USDA-Forest Service cannot avoid its obligations under the National Environmental Policy Act (NEPA) (42 U.S.C. 4321) by arguing that any necessary scientific inquiry concerning pesticide use must be conducted by EPA (Citizens Against Toxic Spray, Inc. v. Bergland, 428 F. Supp. 908, 927 (D. Ct. Or. 1977)). Just because a program involves the use of substances registered under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) does not exempt that program from the requirements of NEPA (Environmental Defense Fund, Inc. v. Hardin, 325 F. Supp. 1401, 1407 (D.D.C. 1971)). The responsible agency may not attempt to abdicate to any other agency merely because that agency is authorized to develop and enforce environmental standards (Calvert Cliffs Coordination Committee v. Atomic Energy Commission, 449 F. 2d 1109, 1123 (D.D. Cir. 1971)).

TABLE 1-2. Litigation involving the Use of Herbicides on National Forest System Lands.

CASE	ACTION
<u>Citizens Against Toxic Sprays Inc., et al v. Bergland, et al., Civil No. 76-438, U.S.D.C., E. D. Oregon.</u>	Use enjoined until NEPA compliance found whereupon application occurred.
<u>Newton County Wildlife Association v. Larry Henson, Forest Supervisor, et al., Civil No. LR-75-C-173, U.S.D.C., E.D. Arkansas.</u>	Use enjoined until NEPA compliance found whereupon application occurred.
<u>Frank J. Kelly, Attorney General, State of Michigan v. Butz et al., Civil No. M74-87CA, U.S.D.C., W. D. Michigan.</u>	Use enjoined until NEPA compliance found whereupon application occurred.
<u>State of Wisconsin v. Earl Butz et al., Civil No. 74-C-304, U.S.D.C. E.D. Wisconsin.</u>	Injunctive relief denied.
<u>Sierra Club v. Clark, Civil No. 73-202-E, U.S.D.C., S. D. California.</u>	Injunctive relief denied.
<u>People for Environmental Progress v. Douglas Leisz et al., Civil No. 73-1405-LTL, U.S.D.C., S. D. California.</u>	Injunctive relief denied.
<u>Indian Action Council, et al. v. Knebel, et al., Civil No. C-76-2407-CCP, U.S.D.C., N. D. California.</u>	Injunctive relief denied.
<u>Fitzgerald v. USDA, Doc. No. 79-1408 Pending before the First Circuit Court of Appeals.</u>	No injunctive relief granted in the district court.

As a result, EIS's prepared for USDA-Forest Service programs using herbicides must consider the potential environmental consequences of the application of those pesticides. Remote or speculative consequences need not be discussed in detail, and it is not necessary that all potential environmental effects be mentioned. However, the EIS must indicate the extent to which environmental effects are uncertain or unknown (Citizens Against Toxic Sprays, Inc. v. Bergland, *supra* at 924, citing Sierra Club v. Froehlke, 534 F. 2d 1289, 1296 (8th Cir. 1976)). Where scientists disagree about the possible adverse environmental effects, the EIS must inform decision makers "of the full range of responsible opinion" (Ibid).

Similarly, the discussion of alternatives in the EIS must go beyond mere assertions and provide sufficient data and reasoning to enable a reader to evaluate the analysis and conclusions and to comment on the EIS. For example, in Citizens Against Toxic Sprays, an EIS concerning the use of 2,4,5-T by the USDA-Forest Service in Region 6 was determined to be inadequate due to its failure to discuss: 1) the toxicity of TCDD; 2) the potential impacts of application on agricultural crops on adjacent private lands; 3) the scientists disagreement concerning the hazards of TCDD; 4) the controversy over the effects of Agent Orange (which contains TCDD) in Viet Nam; and 5) EPA administrative proceedings then taking place against the registration of 2,4,5-T. Injunctive relief was therefore granted with respect to TCDD related cases until such time as the inadequacies of the EIS are corrected. The Citizens Against Toxic Sprays case is currently on appeal to the Ninth Circuit Court of Appeals (R. Fullerton 1979, personal communication).

SUMMARY

Weed management is a topic which existing laws treat superficially within the context of broader resource management and environmental policies. Although some details within a weed management program will be controlled by law, such as registration of economic poisons, by and large, the applicable laws give little direction as to the types of undesirable vegetation that should be managed and how such activities should be conducted. Recently developed regulations for compliance with the NFMA omit specific reference to weeds and how forest and range plans should deal with them. Thus, weed management activities are left to the various functional and research staffs of the USDA-Forest Service.

Environmental laws significantly influence weed management activities by: 1) requiring public participation during the planning stages of proposed projects; 2) requiring environmental assessments and impact statements; 3) regulating the use of chemical herbicides; and 4) restricting the use of prescribed fire which

could impair air quality. These laws provide some direction, through restrictions, to USDA-Forest Service weed management programs.

2.0 POLICIES

Throughout the USDA-Forest Service, several functional groups have the responsibility of controlling vegetation which is detrimental to the planned use of an area. Each unit has particular objectives and guidelines for managing the desirable, as well as the undesirable, vegetation. These directions are found in the sections on each functional unit in the Forest Service Manual (FSM). In addition to these guidelines, the Manual also contains the agency's policy on pesticide use and the NEPA process. A new section on integrated pest management (IPM) is currently being drafted.

This section analyzes the USDA-Forest Service policies relating to weed management as they are stated in the Manual and other directives. IPM policies are analyzed based on the directives of President Carter and Secretary of Agriculture Bergland. Pesticide use policies found in FSM Chapter 2140 are examined for their relationship to weed management. The objectives of functional and research staffs are discussed with specific emphasis on the role weed management plays in meeting these objectives. Lastly, the USDA-Forest Service NEPA process is examined as it relates to weed management.

2.1 Integrated Pest Management

Administrative Directives

On December 12, 1977, Secretary of Agriculture Bergland issued Secretary's Memorandum Number 1929 which states:

"It is the policy of the U. S. Department of Agriculture to develop, practice, and encourage the use of integrated pest management methods, systems, and strategies that are practical, effective, and energy-efficient" (USDA Secretary's Memo. 1929).

Since the declaration of this policy, the USDA-Forest Service and other agencies within the Department have been involved in revising their manuals and methods of operation. The Forest Service Manual was revised in February 1979, and is presently being revised again to establish guidelines for agency compliance with the IPM policies of the Department.

President Carter, in his Environmental Message of August 2, 1979, emphasized that IPM should be encouraged in all Federal research and operational programs. At that time, he directed all Federal agencies to: 1) review all pest management activities to assess their compliance with IPM; 2) modify existing programs to conform

to IPM strategies; and 3) report on the review and modifications to an interagency IPM Coordinating Committee by June 30, 1980 (Council on Environmental Quality 1979). The Office of Environmental Quality in the Department of Agriculture has formed a committee which is currently reviewing the Department's policies and programs.

Forest Service Manual

Current USDA-Forest Service policy reflecting these administrative directives is found under Pesticide-Use Management in FSM section 2140:

"It is Forest Service policy to develop, practice, and encourage the use of integrated pest management methods, systems, and strategies which provide adequate protection against significant pests with the least hazard to man, his possessions, wildlife, and the natural environment. Natural controls and selective measures are to be adapted as rapidly as possible. IPM may include the use of chemical pesticides" (FSM 2140.3).

Other references to IPM in the Manual are presented in the context of Forest Insect and Disease Management prevention and suppression activities (FSM 3403.51).

Weed management with IPM is not specifically addressed in the Manual, but will be included in a new section of the Manual dealing with IPM. This is currently being drafted and reviewed. When implemented, it will contain the new policies, objectives, and authorities, as well as the components of IPM. The importance of the draft to weed management cannot be estimated at this time because this is the first time that the Manual recognizes and designates that vegetative pests are to be managed by similar guidelines as applicable to insects, diseases, and vertebrate pests.

The draft policy of the USDA-Forest Service dealing with IPM is as follows:

"Forest Service integrated pest management policy is to develop, practice, and encourage the use of IPM methods, systems, and strategies which provide protection of forest resources with the least hazard to man, his possessions, wildlife, fish, and the environment. This includes: the use of natural controls and other selective methods that will reduce reliance on chemicals; the management of forest resources in a manner that is not conducive to the development and perpetu-

ation of pest problems; the prudent timing of applications; and the demonstration of effective and workable IPM practices and strategies and encouragement of their acceptance" (draft FSM 2140.3).

An important difference between the draft and the current policy is that the new definition of pest includes "noxious farm weeds and other unwanted vegetation" (draft FSM 2140, Introduction). The inclusion of weeds as pests precipitates changing the organizational structure and responsibilities of the Pesticide-Use Coordinating Committee (PUCC), which has already become the Integrated Pest Management Working Group (IPMWG). This group is chaired by the Deputy Chief for State and Private Forestry.

Environmental and economic aspects of pest management are also stated in the IPM objective:

"(The objective of IPM is) to insure optimal pest management with respect to environmental concerns, biological effectiveness, and economic efficiency while achieving resource management objectives" (Draft FSM 2140.2).

"Optimal pest management," "biological effectiveness," "environmental concerns," and "economic efficiency" are not precisely defined in the Manual, thereby allowing professional discretion in their interpretation. Ideally, by comparing the pros and cons of the biological effectiveness, economic efficiency and environmental considerations of alternative treatments, managers can arrive at an optimal pest management strategy. However, in actuality, some of the most biologically and economically effective management strategies pose the greatest threats to the human and natural environments. Also, the objectives of economic efficiency of pest management, and the criteria as to how efficiency should be determined are unclear.

The revised portions of the Manual also raise organizational questions. For instance, how much will the new IPMWG look at the overall pest programs rather than just specific projects which use pesticides? With the State and Private Forestry Deputy area taking lead responsibility for IPM, does this branch have adequate expertise to develop new management and control programs for weeds as well as insects and diseases? These questions and others are discussed in Section 8.0 of this report as issues to be examined in later phases of this study.

2.2 Herbicide-Use Policies

The latest Forest Service national pesticide-use report indicates that 41 chemical herbicide formulations were used in weed management activities in FY 1978. The policies governing the use of all pesticides are found in section 2140 of the FSM, entitled Pesticide-Use Management. (This section is currently being revised and will be changed to section 2150, Pesticide-Use Management and Coordination.) USDA-Forest Service policy with regard to herbicides, and all pesticides, is as follows:

"1. Pesticides may be recommended and used in operational projects only after consideration of alternatives--based on competent analyses of effectiveness, specificity, environmental impacts, and benefit-cost--clearly demonstrates that the use of the pesticide is essential to meet management goals.

"2. The requirements of Title I of the National Environmental Policy Act must be met...

"3. Only pesticides registered by the Environmental Protection Agency...may be used, except as otherwise provided in regulations, orders, or permits issued by EPA.

"4. The herbicides 2,4,5-T, Silvex*, or other materials containing TCDD may be used only where no other environmentally acceptable and economically feasible alternative, nonchemical or chemical, is registered or available. Cost effectiveness will not be the sole criterion. Herbicides containing TCDD contaminants may be used only after approval by the Assistant Secretary for Conservation, Research and Education (changed to Assistant Secretary for Natural Resources and Environment).

"5. Where endangered or threatened animal or plant species habitat is involved, pesticides may be used only after it is determined...that such use will adversely affect neither the species nor its critical habitat.

"6. Pesticides will not be used in Wilderness areas; (except)...where necessary to prevent the loss of significant aspects of the Wilderness area or to prevent significant losses to resource values on public or private lands bordering the Wilderness. The use of chemicals for controlling outbreaks of insects

*NOTE: 2,4,5-T and Silvex were suspended for use on forests, pastures, and rights-of-way by an EPA emergency suspension on February 28, 1979.

and diseases in a designated Wilderness must be approved by the Assistant Secretary for (Natural Resources and Environment).

"7. Pesticide application and use must be controlled in a manner that ensures adequate safety...Treated areas will be posted with appropriate signs indicating the name of the material used and date of application to ensure that potential forest users...are informed of possible exposure to pesticides. In addition, the project officer will confirm that all persons in or near the treatment areas are notified.

"8. Pesticides and pesticide containers will be transported, stored, and disposed of in accordance with Federal, state, and local laws and regulations.

"9. The rights-of-way management plans of highway, road, transmission line, railroad maintenance departments and others, and county weed control plans will be reviewed and approved by the Forest Supervisor to ensure that all uses of pesticides on National Forest System lands conform to this Directive and Department policy...Use of alternatives to chemical herbicides may be required.

"10. When applying pesticides in sensitive situations, appropriate environmental monitoring will be carried out to determine amount of drift, if any, into nontarget areas and to detect unanticipated nontarget effects.

"11. A comparison of ground and aerial applications...must be made whenever herbicides are to be used. Aerial application methods shall be used only when advantages over ground methods are significant...

"12. Special attention will be given to all restricted-use pesticide handling and use precautions.

"13. The Forest Service shall conduct and support research to develop and to evaluate the effectiveness and environmental safety of pest management technology...and to effectively transfer this technology to minimize costs and adverse environmental and health impacts.

"14. Provide information about possible risks associated with use of or exposure to 2,4,5-T and related compounds containing...dioxin (TCDD) to all employees, regardless of sex or age" (FSM 2140.3(1)-(14)).

These policies became effective in February, 1979 and provide the basis for the policies in the draft Pesticide-Use Management and Coordination Section 2150, which is currently being reviewed. This draft section brings pesticide-use into the context of IPM by changing and/or establishing new authorities and directives, many of which deal with coordination, safety, and recent developments at EPA or USDA involving pesticides.

Pesticide-use policies reflect the need for using the chemicals as well as the public controversy over using them. The policies are formulated so that EPA registered pesticides can be used when alternative management strategies have been evaluated and found to be inadequate for meeting the objectives of the resource managers. Beyond that, the policies require that pesticides be used in a manner which reduce possible adverse impacts to the applicators, other humans, and the non-target species in the treated area.

2.3 National Forest System

Timber Management

The objective of the Forest Service Timber Management staff is to "promote and achieve a pattern of timber resource uses that will best meet the needs of people now and in the future" (FSM 2402). Timber is to be managed according to both the Multiple Use-Sustained Yield Act of 1960 and the RPA/NFMA, which recognize range, wildlife, wilderness, and recreation as outputs of the forest which are affected by timber management activities.

In order to meet this objective, some areas of the National Forests are intensively managed for timber output. Intensive timber management requires that desired trees be given an advantage over undesirable competing vegetation. The Manual directs weed management for timber production as follows:

"Generally, competition from brush, grass, weeds and other vegetation is detrimental to the survival and growth of forest trees..." (FSM 2472.8).

Weed management is used to reduce pest vegetation competition during specific timber management practices like site preparation, release, and thinning.

Timber management policies for National Forest System lands deal in broad terms with timber and forest plans and uses rather than with particular aspects of management like weed control. The policies establish timber production as one of the many resource outputs which must be coordinated in forest plans to attain a wide range of beneficial uses of the forest.

Timber management activities are the responsibility of the District Ranger and these policies provide broad directions through the descriptions of the activities in FSM 2476.1. Policies dealing with the use of pesticides by Timber Management staff refer to section 3442 of the Manual (FSM 2476.7).

Range Management

Forest Service range activities are designed to provide leadership in the management, development, utilization, and conservation of rangelands and to develop the range resources of National Forest System lands for sustained grazing. Both structural and non-structural improvements are made to rangelands to meet the latter objective. In the context used here, weed management, which deals primarily with plant control on rangelands, is a form of non-structural improvement.

Weed management projects are conducted on rangelands for three reasons: 1) to improve forage availability for grazing livestock; 2) to control the spread of noxious weeds; and 3) to improve forage palatability. In the first category, "undesirable plants such as sagebrush, juniper, and chaparral brush" (FSM 2245.12) compete for soil nutrients and moisture with species which provide better forage for livestock. Removing or reducing the numbers of the undesirable plants gives the desired species more access to the necessary plant requirements and space.

A somewhat different approach is taken by the noxious farm weed program. Here noxious weeds, such as thistles, milkweed, white-top, and others, are recognized as posing significant problems for both private and National Forest lands. One of the problems with these plants is that, like insects, they can invade private lands adjacent to National Forests, or colonize in National Forests with seed sources found on private lands. Therefore, the objectives of the Forest Service noxious farm weed program include both the control of the weeds on the National Forests and the prevention of the spread of these weeds to private forests and rangelands (FSM 2253.03). Noxious weeds are defined as such by State legislatures and range officials.

In order to control the spread of noxious weeds more effectively, the Forest Supervisors work closely with state and private landowners whose property adjoins National Forest lands. In some areas, this program is coordinated between the local weed control officer and the Forest Supervisor (FSM 2253.03).

General range management policy statements in FSM 2202 broadly state that the Forest Service will 1) make National Forest System lands suitable for livestock grazing by qualified operations; and 2) manage these lands for a sustained yield of forage. Weed management, as an aspect of range management, is not mentioned in the policy statement but direction for these activities is found in subsequent portions of the Manual.

Range revegetation activities include the controlling of species which compete with the preferred species. Revegetation policies on seeding state that:

"...undesirable competing vegetation will be reduced as necessary to permit establishment of seeded species" (FSM 2245.1).

However, revegetation is limited to projects where: 1) the success of the methods and materials can be predicted; 2) there are no unresolved conflicts with other uses; and 3) cooperation with grazing permittees can be assured (FSM 2240.3).

Section 2245.12 of the Manual deals with the methods available for controlling unwanted vegetation for range improvements. It lists control techniques as chemical, mechanical, prescribed burning, or biological methods. Mechanical methods are to be used when "a) competing vegetation is resistant to herbicides, and b) herbicides may cause damage to desirable vegetation or other values" (FSM 2245.12). The implication is that chemical treatment is preferred over mechanical in most cases with the exception of these two situations. If this is the case, it is clearly contrary to the IPM concept and pesticide-use policies which state that pesticides are to be used only after all alternative treatments have been considered and found to be inadequate to accomplish management objectives (draft FSM 2150.3(1)).

Lands Management

The Lands staff of the USDA-Forest Service is also involved in weed management and control by virtue of its power to issue special use permits to a wide range of interests, many of whom have the need to control vegetation. The diversity of special use permittees who need to manage vegetation includes public utilities, i.e., gas pipelines, electricity transmission lines, and water pipelines, as well as recreational developers which manage

ski areas, golf courses and other areas.

Each special use permittee has unique objectives and criteria for maintaining or managing the vegetation. For instance, utilities need to be sure that their facilities are accessible in case of emergency or for routine maintenance and free from tall-growing vegetation that interferes with electric transmission lines. Because of the varying conditions required by each special use permittee, the USDA-Forest Service requires the permittee to manage the special use areas in conjunction with the District Ranger. However, permittees are required to prepare annual plans if they are expecting to use any type of pesticide. Such plans must be approved in writing by the Forest Supervisor (FSM 2783.1, Interim Directive No. 14).

Fire Management

The Fire Management staff practices weed management to reduce the threats of fire by manipulating live vegetation and the accumulation of dead vegetation in litter. In forest and range areas which are highly susceptible to fire,

"The basic objective is to alter the fuel conditions sufficiently to reduce the threat of fires starting and to facilitate suppression of fires that occur, or both" (FSM 5152.02).

To meet this objective, some type of management or alteration of the existing vegetation is required. Once altered, the vegetation often requires maintenance treatments. Thus, the fuel modification programs resemble other weed management activities in that the pest vegetation causes adverse effects (in this case, fires) on the resources and is to be managed accordingly.

National fuel management policy requires the Regional Foresters to prepare planning guides for natural and man-created fuel hazard plans. All projects which generate fuels or are undertaken to reduce natural fuels must include fuel treatment plans (FSM 5150.3).

Weed management for fuel reduction involves the removal of some or all of the hazardous vegetation to reduce potential fire ignitions, spread, or intensity. The Manual lists prescribed burning, hand and mechanical removal of brush, construction of fuelbreaks and firebreaks, and vegetation type conversion as fuel modification treatments (FSM 5152.22).

Engineering

The Engineering staff of the USDA-Forest Service oversees the control of unwanted vegetation along road rights-of-way located on National Forest lands and is therefore involved in weed management. In many instances, the roads crossing the National Forests are Federal, state, or local highways, and it is up to the appropriate highway departments to maintain the road rights-of-way. The Engineering units work with the District Rangers and Forest Supervisors to oversee road maintenance by the states and local governments. The objectives of road maintenance are to insure adequate visibility for safety and to provide scenic vistas along the roadsides.

Recreation Management

The Recreation staff is directly involved in weed management only through its part in the clearing and maintenance of campgrounds, trails, picnic areas, and other facilities, and is indirectly involved through its input in the planning of all Forest resource uses. The objective of the Recreation staff is to "encourage and enhance public outdoor recreation on National Forest System lands" (FSM 2301). In order to provide greater recreational opportunities, certain plants which interfere with recreational uses may require control and management. In this context, weed management can be considered an aspect of recreation management, albeit a small one.

Wildlife Management

The Wildlife and Fish Management staff is charged with: 1) maintaining and improving wildlife habitat on National Forest System lands; 2) coordinating Forest Service wildlife management guidelines with other activities on the National Forests; and 3) giving special attention to state and other Federal wildlife programs such as endangered species and designated sensitive habitat areas (FSM 2602). Although some of its work involves weed management (as defined herein) for direct habitat manipulation, most of the wildlife staffs' efforts are directed at advising Timber, Range, and other management staffs on the effects various practices have on wildlife. Wildlife management activities are often an integral part of other resource activities and are implemented concurrently.

The policies directing Forest Service wildlife management (FSM 2603) closely parallel the objectives given above and do not specify how the activities relate to weed management.

2.4 State and Private Forestry/Forest Insect and Disease Management

The Forest Insect and Disease Management (FI&DM) Chapter of the Manual (FSM 3400) describes the authorities, objectives, and policies of the staff, none of which indicate that the staff plays an important role in weed management. FI&DM involvement with weed management is due to the presence of its expertise on pest control (which to most people is insect and disease, not weed, control) and the use of pesticides. Therefore, when pesticides of any kind, including herbicides, are used, the FI&DM staff is likely to be involved, even if only in the final stages of project planning or environmental assessment.

FI&DM is part of the State and Private Forestry (S&PF) Deputy Area. The Deputy Chief for S&PF is responsible for the control and use of pesticides (FSM 2140.42), and serves as Chairman of the Integrated Pest Management Working Group (IPMWG). The Director of FI&DM is the vice chairman of the IPMWG and the Executive Secretary is also a member of the FI&DM staff (currently the Assistant Director). FI&DM personnel occupy the key positions on this group "to ensure full coordination across all functional lines engaged in pesticide-use management" (FSM 2140.43).

Similar situations exist in Regional and Area Offices where FI&DM expertise on pesticide use results in the FI&DM staff members becoming involved when herbicides are used on National Forest System lands. In some cases, FI&DM pesticide specialists are called to prepare environmental assessments and statements for weed management projects.

Another important role of FI&DM is that members of its staff usually fill Forest Service positions on departmental and inter-governmental pest management committees. They are obvious candidates for such positions because of their expertise in pesticide-use, entomology, and pathology. However, when weeds are considered pests, most FI&DM personnel lack expertise. This brings up the question of which staff unit in the Forest Service best represents the weed component of pest management. On departmental activities, the USDA-Forest Service is often represented by members of FI&DM and Timber Management Research.

2.5 Research

The Research Deputy Area is actively involved in weed management and IPM research studies. The draft IPM Manual revision states:

"It is Forest Service policy to conduct and support research to develop and evaluate the effectiveness and environmental safety of new pest management technology including new and improved silvicultural techniques, pesticide formulations, applications, and monitoring techniques, and alternative pest management methods and tools" (Draft FSM 2140.3).

According to the new policies, weed management research is to emphasize 1) development of natural controls and selective methods that reduce reliance on herbicides and 2) silvicultural and range management practices which prevent weed problems. Researchers are also directed to develop models which integrate weed management objectives with resource management and environmental criteria. Prior to the IPM Manual revisions, Research policies for weed management were found in the policies of the functional Research staff groups, primarily Timber Management Research (TMR) and the groups which were combined into Forest Environment Research (FER)-Range and Wildlife Habitat Ecology and Management Research, Watershed and Aquatic Habitat Research, and Forest Recreation and Related Human Environment Research.

Policies of the Research Deputy Area call for the Forest Service to: 1) carry on high priority research for the management, protection, and utilization of timber, water, range forage, wildlife, and recreation; 2) conduct research only within approved Research units; 3) disseminate results of the research to interested public and private agencies and individuals; and 4) assist users in applying research results (FSM 4060.3). Research units are to work closely with the National Forest System and State and Private Forestry Deputy Areas to determine what research is needed and ensure that it can be implemented. From these broad directives, the functional Research staffs develop research programs in accordance with the Research Work Unit plans as described in FSM 4050. Subsequent sections of the Manual cover the goals of each staff but do not develop different policies for each functional staff.

Timber Management Research

The objectives of the TMR staff, as found in FSM 4110, are to conduct research on all aspects of timber management including: 1) improving the yield and quality of timber; 2) extending supplies of natural timber resources; and 3) protecting and improving the quality of the environment on public and private lands. Silvicultural research which includes studies on seed production, planting, thinning, pruning, stand regeneration, and cutting; and research on the control of brush and other competing vegetation are two topics which the Manual mentions but provides little specific direction as to the implementation of such studies.

TMR's responsibility to develop brush control technologies has brought it to the forefront of the controversies on the use of herbicides on National Forests, where it will continue to play a major role as alternative methods of managing timber-related weeds are studied. The Washington Office TMR staff has become the unit where weed management expertise tends to be located, and members of this staff frequently represent the Forest Service on agency, departmental, and interagency weed management committees and advisory boards.

Forest Environment Research

FER is the Forest Service staff responsible for conducting research on range, watershed, wildlife management, utilization, protection, recreation, and surface mining activities. The policies and objectives of FER are contained in three chapters of the Manual - Range and Wildlife Habitat Ecology and Management Research (FSM 4210), Watershed and Aquatic Habitat Research (FSM 4310), and Forest Recreation and Related Human Environment Research (FSM 4910).

Range, wildlife, and watershed research are given broad general objectives of studying and developing ecosystem and habitat models to aid in the protection, utilization, and management of the resources. The guidelines in the Manual are so broad that they provide little direction as to what should or should not be done, thereby leaving researchers and managers broad discretion in developing research programs.

The direction provided recreation researchers is similar but the objectives of recreation research differ greatly from those of range, wildlife, and watershed management research. For instance, recreation research activities are to: 1) determine the motives, needs, and experiences of the public; 2) develop methodologies to evaluate recreational experiences; and 3) determine what the benefits of recreation are to society. The knowledge that this research provides about the socio-psychological aspects of recreation can then be used by recreation planners to coordinate forest land uses.

2.6 Forest Service NEPA Process

In order to comply with the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321), the Forest Service has developed a set of policies and guidelines to assure that an environmental assessment (EA) and/or environmental statement (ES) is part of all planning and decision-making activities. Assessments are conducted by interdisciplinary teams according to the directives found in FSM Chapter 1950 - the Forest Service NEPA Process. Preparation of an EA and activities which result from it, such as an ES, make

up the "process."

The NEPA process is a multi-staged systematic approach which formalizes Forest Service methodology. It adheres to the steps found in FSM 1952 which are to:

1. Identify issues, concerns, and the need for a decision.
2. Select criteria and standards on which to base the assessment.
3. Gather related information on present and future conditions.
4. Formulate a reasonable range of alternatives to address the issues and concerns identified in Step 1.
5. Analyze the direct, indirect, and cumulative effects of implementing each alternative.
6. Evaluate current and future outputs and changes of each alternative.
7. Identify the Forest Service preferred alternative based on the analysis and evaluation of Steps 5 and 6.

Upon completion of these steps, a decision is made and documented in an environmental assessment report (EAR) as to what additional environmental analysis and decision-making activities are needed to complete the NEPA process.

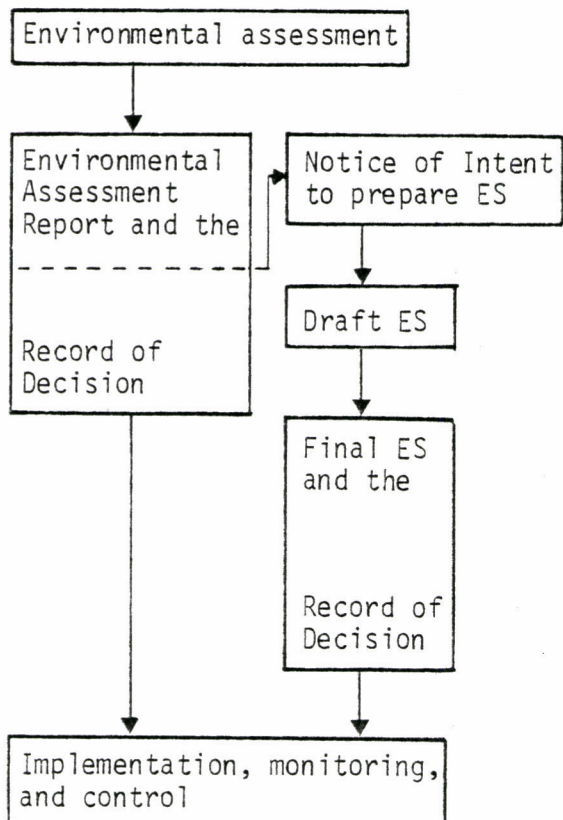
An environmental assessment yields one of two decisions (Figure 2-1). If the EA finds that the proposed action will have no significant impact to the environment, then a record of that decision is filed in the environmental assessment report (EAR). On the other hand, if the assessment finds that the proposed activity is a major Federal action significantly affecting the environment, then an ES is prepared. ES's are detailed reports on the proposed activity and its effects on the environment. The significance of preparing adequate ES's cannot be overestimated because NEPA has been the basis for many court challenges to weed management and other Forest Service activities (see Section 1.3).

SUMMARY

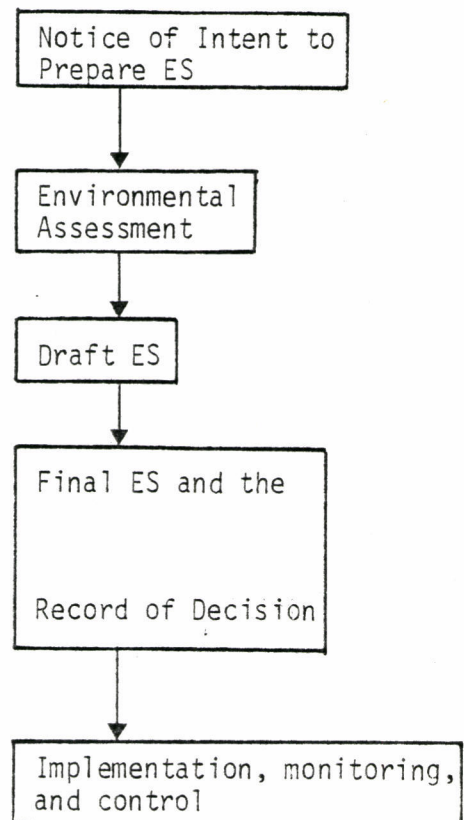
Weed management activities are authorized through USDA-Forest Service directives of various resource management staffs. The directives indicate that undesirable vegetation should be managed to provide a competitive advantage to more desirable trees and forage plants, and to remove potential fire and safety hazards associated with rights-of-way and roads. The policy statements of these resource staffs deal broadly with managing the resources to assure product outputs while improving and/or maintaining environmental values. Accordingly, these policies do not specifically address weed management.

FIGURE 2-1. The NEPA Process (FSM 1950).

When the need for an ES has not
been determined:



When the need for an ES has
been determined:



Revisions to the pesticide-use and IPM policies indicate that weeds are considered to be pests. As such, they are to be managed according to the principles of IPM (draft FSM 2140). Even though weeds have previously been included as pests in relation to pesticide-use (FSM 2140.5(2)), the Manual revisions address weeds in the same context as they do insects, diseases, and rodents. The IPM revisions of the Manual also specify that Research is to undertake studies which will provide managers with alternative strategies that integrate environmental, resource management, and pest management factors.

3.0 ORGANIZATION AND ADMINISTRATION

3.1 Forest Service Internal Organization

The Forest Service organizational structure is made up of five branches (called Deputy Areas) with three to four distinct levels of authority in each (Figure 3-1). Of the five Deputy Areas, three - the National Forest System (NFS), Research, and State and Private Forestry (S&PF) - are involved in weed management. The organizational hierarchies within each of the branches are similar with regard to responsibilities and authorities.

At the peak of the organizational structure is the Chief, who is ultimately responsible for all functions and activities of the agency. Below the Chief is the second level of line authorities: Regional Foresters of the NFS; Experiment Station Directors of the Research Deputy Area; and S&PF Area Directors.* Making up the third level of line authority are the Forest Supervisors (NFS) and Research Project Leaders. The District Rangers are at the base of the administrative pyramid of the NFS. A Deputy or Associate position may exist which reports to the line officer and has specifically delegated line authority.

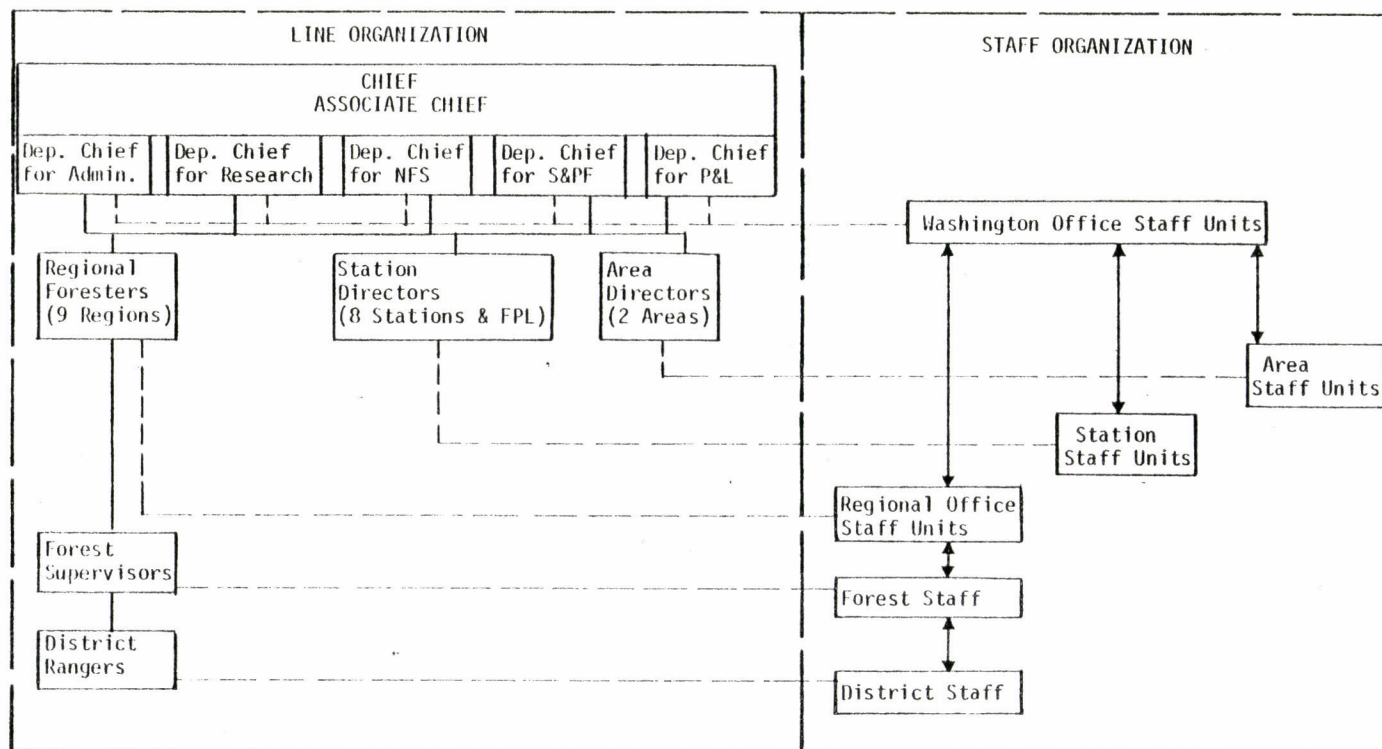
Throughout the USDA-Forest Service there is a general tendency of decentralization of authority and responsibility. The District Rangers are responsible for the actual planning and implementation of land and resource management projects. Above the Rangers are three organizational levels, each charged with the task of reviewing, approving, and recommending the project which the Rangers carry out. The Forest Supervisors approve, recommend, and inspect the activities on the Districts, the Regional Foresters advise, approve, and inspect the Forests, and the Chief and the Washington Office staff do the same for the Regions.

Similar situations exist in both S&PF and Research Deputy Areas, although the staffs of these are not as large. In S&PF, there are two levels of line authority, the Chief and the Area Director, both of which have supporting staffs. The Research Deputy Area line authority begins with the Project Leader and passes to the Experiment Station Director and the Chief.

As an example, Washington Office staff supports the Chief and Deputies by advising them on policy, program direction, and budget matters. Experts on all aspects of agency activities make up the Washington Office units. Even though this staff lacks the line

* There are two S&PF Area Directors, one in the southeast and one in the northeast. In Regions 1, 2, 3, 4, 5, 6, and 10, the Regional Foresters assume S&PF program responsibility.

FIGURE 3-1. Roles and Line-Staff Relationships (Source: FSM 1206).



authority to assure implementation of programs, the individuals in the Washington Office maintain considerable leverage over Regional, Area, Forest, and Experiment Station programs by virtue of their working at the top levels of the organization (Robinson 1975). The level of influence which the Washington Office staff exerts over field staff and activities varies with individuals and positions throughout the agency.

National Forest System

Weed management projects and all other managerial and administrative activities on National Forests are the responsibility of personnel in the National Forest System. The NFS organizational hierarchy is described above and illustrated in Figure 3-2, which points out that weed management activities and responsibilities are diffused throughout the agency. Various staff groups in the Washington, Regional, Forest, and District Offices provide expertise to manage the natural resources.

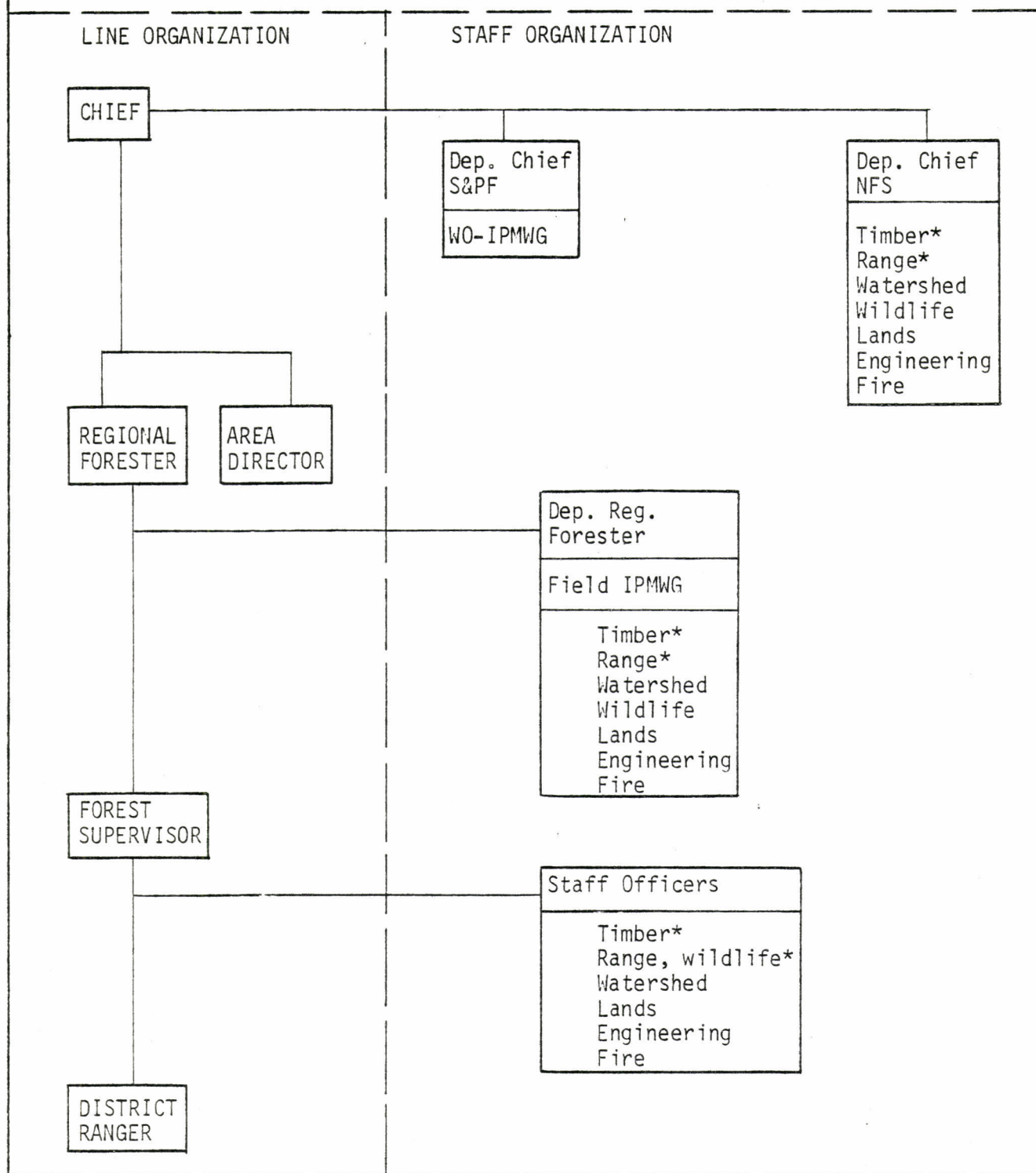
For instance, the Timber Management staff may be concerned with controlling competing vegetation that is stifling growth of trees. Range Management staffs may be more interested in improving forage conditions and palatability. Other NFS staffs such as Wildlife, Recreation, Lands, Watershed, Fire Management, and Engineering all have special uses for, and therefore interests in, controlling unwanted vegetation. Thus, weed management is conducted in the field by these staff groups in conjunction with the District Rangers and Forest Supervisors.

As a result of weed management generally being left to the various resource management staffs, there is no staff unit charged with reviewing and coordinating all the agency's weed management activities. (One exception to this is Region 8, which has a vegetation management specialist.) Under the existing organizational situation, it is difficult to determine the magnitude of the various weed programs, who the agency spokespeople are for weed management, and how weed projects are coordinated, reviewed, and approved. As a result, separate weed management projects are often autonomously conducted by several functional units.

In a recent speech, Assistant Secretary of Agriculture Cutler called on the Forest Service,

"to establish a research and implementation approach that will provide centralized expertise on the management of pest vegetation. This action will give the management of pest vegetation the same high level of technology development and program direction that we now have for insects and diseases" (USDA-Office of the Secretary, Oct. 3, 1979) (Emphasis added).

FIGURE 3-2. Weed Management Organization.



*denotes major vegetation management units.

An official request for such an approach was sent to the Forest Service two days prior to the speech. A task force, consisting of representatives from FI&DM, Timber Management, Range Management, Forest Environment Research, Timber Management Research, and Programs and Legislation, has been formed to recommend how and where a new unit would function, if one is formed. A report on the task force recommendations is expected by March 1, 1980.

Several options for centralizing weed expertise are available. These include, but are not limited to:

- 1) Establishing a weed management work group with representatives from each functional area involved in weed management and research. Such a work group would require that individuals from the functional areas have expertise in weed management. The resource and research staffs involved in weed management would concentrate on weed problems internally, and use a work group for developing strategies for all weed activities.

- 2) Adding weed management experts to existing FI&DM and FI&DR staffs. Under this option, weed specialists would coordinate weed management activities on National Forests with appropriate staffs, similar to the manner in which entomologists do now.

- 3) Establishing a weed management unit in the NFS Deputy Area which would coordinate weed projects of all resources, i.e., Timber, Range, Wildlife, Watershed, Recreation, Engineering, and Lands. A similar unit in the Research Deputy Area would bring together scientists now in Timber Management and Forest Environment Research.

Implementation of any of these options has many pros and cons. Maximum recognition of weed management as a science and a problem area might be accomplished by Option 3. At the same time, it would require more changes in the organization and responsibilities than Options 1 or 2. In some ways, Options 2 and 3 would require duplication of expertise between the weed (or pest) experts and the land managers. Bringing together experts from all the resource units involved in weed management into one group would seemingly create a staff so complex that it could be difficult to determine its specific responsibilities and authorities. Option 1 would precipitate less change in the existing organization than the other two, but it may not provide the significant change for which the Assistant Secretary seems to be asking.

State and Private Forestry

S&PF staff groups are involved in weed management through their expertise on pesticides and their positions on the Integrated Pest Management Working Group (IPMWG), which was formerly the Pesticide-Use Coordinating Committee (PUCC). In most Regions, pesticide expertise is located in the Forest Insect and Disease Management (FI&DM) staff, which may be called on to prepare or assist in the preparation of EA's and ES's.

The Deputy Chief of S&PF has the responsibility for representing the agency on all aspects of pesticide-use and coordination, including chairing the PUCC (FSM 2140.42). The draft of the Manual dealing with IPM creates the IPMWG and delegates broader authority to the Deputy Chief for S&PF. When the draft becomes official, the Deputy Chief will have "the responsibility for coordinating integrated pest management activities," and serving as chairman of the Washington Office IPMWG (draft FSM 2140.42).

The Washington Office-IPMWG is a coordinating committee which addresses all aspects of IPM including weed management and pesticide-use. However, the group does not have authority to approve or alter projects. Accordingly, the Deputy Chief for S&PF is delegated the responsibility for coordinating IPM but not the authority to initiate, plan, implement or approve actual weed management projects. At this time, it is unclear as to what the Deputy Chief's "responsibility for coordinating" IPM entails and how it may change.

In the Regions, field IPMWGs have replaced the field PUCCs. The Deputy Regional Foresters or Assistant Station and Area Directors will chair these groups, whose function will be to encourage "the implementation of Forest Service IPM policy" in the field by reviewing all pest control and management activities (draft FSM 2140.45b). It is not clear how the field IPMWGs and the Regional chairmen will function in light of the Manual changes and task force recommendations.

Research

The Research Deputy Area follows the Line/Staff organization structure of the other deputy areas. Authority descends from the Chief to both the eight Station Directors and the Deputy Chief for Research, who is responsible for coordinating, planning, and directing all Research programs.

There are seven functional Research staffs in the Washington Office which advise the Deputy Chief. Three of the functional Research staffs--Timber Management Research (TMR), Forest Environment Research (FER), and Forest Fire and Atmospheric Sciences

Research (FFASR)--are involved in weed management for forestry, range, wildlife habitat, and chaparral.

Organization of the Experiment Stations is by Research Work Units (RWU's). Authority at the stations descends from the Station Director to Assistant Directors for Research to Project Leaders and Program Managers. Project Leaders head the RWU's. Organizing staff scientists according to RWU's allows flexibility for scientists to participate on studies within their specific area of expertise and on teams where diverse expertise is required.

Weed management is conducted through functional and multifunctional RWU's. Narrowly defined problems and early stages of research are conducted through Functional Research Work Units. Multidisciplinary FRWU's or Multifunctional Research Work Units are developed to bring together scientists from several fields to work on common problems.

Delegation of Authority

The USDA-Forest Service Chief is ultimately responsible for all agency programs and administration, and delegates most of the operational responsibilities for land and resource management to the Regional Foresters. It is the prerogative of the Regional Forester to transfer some of these responsibilities to the Forest Supervisors and, in many cases, District Rangers, thus, perpetuating the agency's tradition of decentralization of authority.

Robinson (1975) points out that the power of the Regional Forester to delegate his authority results in a system where the different Forest Supervisors' jurisdiction varies significantly. The same is true of the Forest Supervisor's ability to assign his authority to the District Ranger and the varying degree of authority of each Ranger. However, Kaufman (1960) notes that even though a District Ranger may be delegated authority officially, his responsibility is not to make independent decisions but to "perform" his functional role according to the Manual, with its regional and forest supplements, and Forest Service Handbooks.

The responsibility for controlling vegetation in conjunction with reforestation, timber stand improvement, range improvement, right-of-way maintenance, and others, is generally delegated to the District Rangers (Table 3-1) by the Forest Supervisors (FSM 2476.04, 2240.4, and 2783.1 I.D. No. 15). The Ranger's responsibility is to perform the resource management activities above. However, the Ranger's authority is limited if herbicides or other pesticides are used. If herbicides are not to be used, the Ranger retains the responsibility of managing, or as Kaufman (1960) would say, "performing" the resource management activities.

TABLE 3-1. Delegation of Authority for Weed Management.

1. 2,4,5-T and other chemicals containing TCDD	Assistant Secretary
2. Other herbicides	Regional Forester and Forest Supervisor
3. Timber stand improvement	District Ranger
4. Site preparation	District Ranger
5. Range revegetation	Forest Supervisor
6. Special use permittee approval	Forest Supervisor

3.2 USDA-Forest Service Functions Within the Department of Agriculture

As an agency within the Department of Agriculture (USDA), the USDA-Forest Service participates in a wide variety of formal and ad hoc committees, task forces, and working groups. One or two members of the Washington Office staff usually represent the Forest Service on these intra-USDA committees and the departmental working groups which coordinate activities with other agencies (see Section 3.3). Although none of these intra-USDA committees deal specifically with weed management, several work groups are organized to coordinate pest management and toxic substances.

The USDA-Environmental Quality Committee is made up of administrators of USDA agencies, including the Chief of the Forest Service. The Assistant Secretary for Natural Resources and Environment serves as chairman, and the Director of the Office of Environmental Quality is the Executive Secretary of the committee. There are five subcommittees and work groups which are germane to weed management.

The work groups are established to bring together expertise on various environmental issues and to enhance environmental coordination in the department. Table 3-2 shows the five intra-USDA environmental issue groups and committees pertinent to weed management and the position of the USDA-Forest Service representative on each. Forest Service participants on the work groups come entirely from State and Private Forestry. There are no representatives from either National Forest System weed management action programs, i.e., Timber Management, Range Management, Land Management and Engineering, or from weed science researchers in Timber Management Research or Forest Environment Research.

In addition to the formal groups mentioned above, the USDA-Forest Service has two representatives on the ad hoc USDA task force to evaluate IPM in order to respond to President Carter's memorandum. As with the participants of the standing committees, both these Forest Service representatives are from the insect and disease sectors of pest management.

3.3 Forest Service Interdepartmental Activities

There are two major areas where representatives from the USDA-Forest Service interact, on behalf of or in cooperation with USDA, with other Federal agencies involved in weed management. These are the joint USDA-Department of the Interior (USDI) Weed Committee and the USDA-Environmental Protection Agency (EPA) Rebuttable Presumption Against Registration (RPAR).

TABLE 3-2. Inter- and Intradepartmental Committees (Sources:
 (1) Office of Environmental Quality, Memorandum, Nov. 20, 1978
 (2) Office of Environmental Quality, Memorandum, Sept. 17, 1979)

GROUP	FOREST SERVICE REPRESENTATIVE
A. Environmental Issue Committees ¹	
1. Environmental Quality Committee (EQC)	Chief
2. Pest Management Subcommittee of the EQC	Chief
3. Steering Committee for the National Agricultural Pesticide Impact Assessment Program (NAPIAP)	Assoc. Dep. Chief, S&PF
4. Work Group on Pest Management	Director FI&DM Alternate: Dir. FI&DR
5. Toxic Substances Control Act Work Group	Asst. Director FI&DM for Pesticides
B. USDA IPM-Evaluation Task Force ²	
	Director FI&DM FI&DR staff
C. USDA-USDI Weed Control Committee	
	1 TMR and 1 FI&DM staff member
1. Integrated Weed Management Systems Work Group	TMR
2. Biological Control of Weeds Work Group	FI&DM (Chrmn), TMR
3. Aquatic Weeds Work Group	TMR
4. Preventative Weed Control Technology Work Group	FI&DM

USDA/USDI Weed Committee

The USDA-Forest Service cooperates with other Federal agencies in weed management on an intergovernmental level through the USDA-USDI Weed Committee. Although technically consisting of two distinct coordinating bodies responsible only to their respective Secretaries, the USDA and USDI have been meeting informally in this forum on a voluntary basis for approximately the last 15-25 years (Seldon 1979, personal communication; Shaw 1979, personal communication). There are neither mutual memoranda of understanding nor procedural guidelines governing operations. Tradition and strong professional ties among agency personnel appear to provide sufficient foundation for cooperation. The Committee's policy-level representatives meet approximately four times annually (Seldon 1979, personal communication). They report on recommendations directly to their appropriate departmental heads.

The brunt of committee work is accomplished by four specialized working groups: a) integrated weed management systems; b) biological control of weeds; c) aquatic weeds; and d) improvement of preventative weed control technology. The USDA-Forest Service has at least one representative on each of these committee work groups (Seldon 1979, personal communication). The principal USDA-Forest Service representatives on the committee and working groups are from FI&DM and TMR. They are primarily involved in the first three of the above work groups, with the FI&DM representative serving as chairman of the biological control of weeds group (Shaw 1979, personal communication). As with the intra-USDA committees, the functional staff units in the NFS have little or no involvement with this group.

Unlike the main committee, working groups operate in terms of individual charters (approved by the joint USDA/USDI committee) which outline consultative goals as well as delegate responsibility to participating governmental officials. Depending on their specialty, working groups retain the right to invite representatives from any other Federal agencies, e.g., Tennessee Valley Authority, the Corps of Engineers, etc.

At least one working group - improvement of preventative weed control technology - is scheduled to disseminate an issue paper on the desirable role of various governmental departments in the area of weed management. A considerably broader series of weed control policy and legislative recommendations, generated by the four working groups at the behest of the joint committee, are also expected to be reformulated into a committee position document some time in the near future.

The USDA/USDI Weed Committee represents a coordinating mechanism whereby USDA-Forest Service personnel interact on a continuing, and to all indications, satisfactory basis with other Federal agencies. It is a good example of the USDA-Forest Service working well through an interagency cooperative mechanism to broaden intergovernmental linkages through the USDA.

Rebuttable Presumption Against Registration (RPAR)

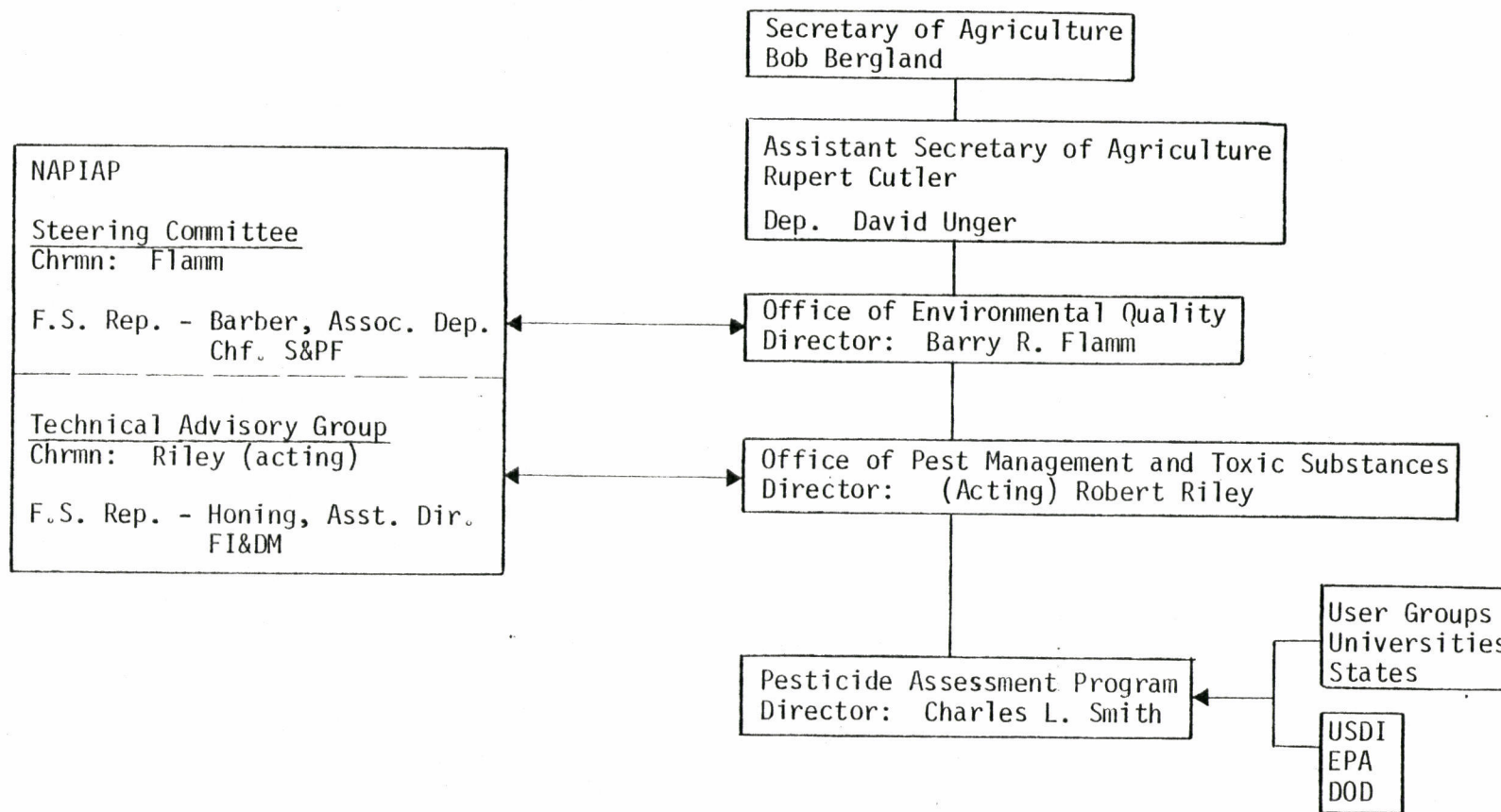
In 1970, EPA assumed the regulatory responsibility for chemical pesticide registration. A subsequent administrative interpretation of existing criteria necessary for registration determined that a more effective mechanism would be needed to evaluate attainment of the criteria. EPA and USDA established the Rebuttable Presumption Against Registration (RPAR) process in 1975 to provide a structure whereby both agencies gather and assess information on the comparative benefits and risks for continued chemical registration and use. The RPAR process was formally initiated by a joint USDA/EPA memorandum of understanding signed initially in November/December 1976, and later revised in October 1977 and January 1979.

RPAR is the regulatory mechanism established by joint memoranda of understanding between EPA and USDA to gather information on the risks, benefits, and exposure levels of pesticides when it has been determined that certain risk factors have been exceeded and that cancellation of the chemical(s) may be warranted. Forest Service participation in the RPAR process is achieved through the USDA National Agricultural Pesticide Impact Assessment Program (NAPIAP), which is made up of a Steering Committee, a Technical Advisory Group (TAG), and individual pesticide assessment teams (see Figure 3-3).

The sequence of events in the RPAR process is initiated by the EPA's determination that an assessment is needed. The USDA's TAG then recommends assessment team members primarily from USDA agencies and EPA, with additional members coming from states, universities, or other Federal agencies. EPA has the responsibility for determining and assessing risks whereas USDA assesses benefits and exposure. The teams collect data on biological and economic benefits, and chronic and acute exposures which might relate to the registered uses; they also identify data gaps that might be reasonably filled. Teams then formally report their findings to EPA.

The next step is for EPA to analyze the risks and benefits as stated in the assessment team reports. Based on this analysis, the Administrator of EPA determines whether to approve the pesticide for continued use or to cancel some or all of the chemical's uses. If the Administrator exercises the cancellation option,

FIGURE 3-3. USDA NAPIAP/RPAR Organization (Source: Office of Environmental Quality, Charles E. Smith, Internal memorandum, June 20, 1978).



registrants (usually industry) still have the opportunity to request a judicial review of the decision.

The level of USDA-Forest Service participation on joint RPAR assessment teams with colleagues from both EPA and other USDA agencies depends upon: a) the nature of the pesticide under study and its relation to forest weed, insect, or disease control; and b) the discretion of a USDA-wide Technical Advisory Group (TAG). Under NAPIAP, TAG plays a primary role in assigning RPAR team memberships to relevant USDA agencies such as the USDA-Forest Service. TAG recommendations are regularly reviewed but seldom altered by the USDA Steering Committee, which monitors pesticide registration from a departmental policy-making perspective. USDA-Forest Service personnel, primarily from TMR and FI&DM units, were leaders on the 2,4,5-T RPAR assessment team, the only assessment team formed to review a herbicide used in forestry.

Based on the relatively brief existence of RPAR (4 years), it is difficult to determine the overall effectiveness of the USDA/EPA cooperative relations. Several factors contribute to this situation. To begin with, the RPAR process has turned out to be a far more intensive and semi-permanent decision-making mechanism for pesticide assessment than was initially envisioned. Once in operation, the procedure has proven to be drawn out considerably and at times rather cumbersome to complete according to joint agency work schedules. In some cases, it has been stymied by certain interagency biases and prejudices. These problems are further aggravated in part by the divergent division of RPAR tasks: USDA evaluates the benefits and EPA assesses the risks quite separately.

RPAR has been evolving rapidly since its establishment. Accordingly, joint agency guidelines directing the assessment teams' methodologies have also been dynamic and relatively short-lived. Because of the ever-changing requirements of specific pesticide teams, strategies, and assessment substance, one USDA official concluded that of the eleven RPAR assessment reports completed to date, none could be characterized as truly typical. Each pesticide issue arising to date has proven to be unique in substance as well as the style in which it was processed.

In many ways, the RPAR mechanism has benefited from this flexibility. However, the flexibility has also resulted in cooperative problems. For instance, members of the two agencies have experienced some difficulty arriving at jointly acceptable formats for economic cost/benefit criteria. Without common criteria for assessment, comparison of the benefits and risks can be greatly hindered. On some occasions, failure to resolve problems like this have disrupted RPAR assessments. Discussions with former RPAR assessment team members from USDA, the Forest Service, the

EPA, as well as non-Federal entities, all seem to indicate that working relationships on some teams often hinder efficient co-operative analysis.

2,4,5-T RPAR

The only RPAR assessment completed to date which directly affects Forest Service weed management activities is on 2,4,5-T (2,4,5-Trichlorophenoxy acetic acid). EPA issued the notice for an RPAR based on potential oncogenic (tumor forming), teratogenic (causing malformations), and fetotoxic (damaging to fetus) risks to humans (43 Fed. Reg. 17116, April 21, 1978).

A NAPIAP team was formed to conduct the assessment and prepare the assessment report. The team was chaired by Logan Norris from the Forest Service Pacific Northwest Forest and Range Experiment Station and composed of 17 other members and some 22 additional contributors from the Forest Service (13), other USDA agencies (8), state universities and forestry commissions (14), and EPA (5). The report was finalized February 15, 1979.

On February 28, 1979, the Administrator of EPA ordered the emergency suspension of 2,4,5-T and Silvex (a related compound which was not originally included in the RPAR) on forests, pastures, and rights-of-way. Use of 2,4,5-T on rice, rangeland, and non-crop uses was not suspended (44 Fed. Reg. 15874, March 15, 1979). The emergency suspension ended the RPAR review for those uses which were suspended. EPA based its decision to suspend the use on the determination that: 1) the suspended uses appear generally to cause unreasonable adverse effects on the environment; and 2) there are uncertainties in the data relating to the risks and benefits of the suspended uses. EPA plans to hold public hearings (the so-called 6(b)(2) hearings because of the FIFRA section) to collect additional data on the risks and benefits of suspended uses.

Reaction to the EPA emergency suspension was mixed. Those who opposed use of the chemical were less than fully satisfied because use of 2,4,5-T is allowed on the non-suspended uses, and they felt that registration for all uses should have been cancelled. On the other hand, proponents of the use of 2,4,5-T felt that the emergency suspension by EPA circumvented the established RPAR procedures by ending the RPAR review with the emergency suspension. At their national meeting in May, the NAPIAP State Liaison Representatives and Regional Coordinators expressed considerable displeasure on the suspension action and felt that it irreparably damaged both the RPAR process and NAPIAP. Caught in the middle of the controversy were those who felt that RPAR had indeed functioned properly with EPA having made its decision based on relevant, available data.

SUMMARY

The existing USDA-Forest Service organization for weed management is such that each resource staff group, e.g., Timber, Range, and Wildlife, maintains its own separate expertise for managing plants that are considered weeds. There is currently no central staff, task force, or working group charged with managing and conducting research on weed management. However, the agency is presently analyzing alternatives to bring together expertise on weed management.

In the Washington Office of the Forest Service, two staff groups--FI&DM and TMR--function as representatives of the agency on weed management issues. FI&DM does so through its responsibilities to coordinate pesticide use. Recent controversies over herbicides have brought FI&DM to the forefront of most weed management activities. TMR is involved because several TMR staff people developed expertise on brush management and control. However, neither of these staffs have direct responsibility for controlling vegetation. That responsibility lies with the various National Forest resource staffs which manage weeds as part of their overall programs.

As a unit of the Department of Agriculture, representatives of the Forest Service serve on several intra- and interagency work groups and committees which deal with pests and pesticide management through the USDA-Office of Environmental Quality. Some of the committees meet once or twice a year to discuss updates of policies and various problems of interest to the committee. Others are involved in both policy matters and specific regulatory problems.

4.0 WEED MANAGEMENT AND RESEARCH ON COMMERCIAL FOREST LANDS

Weed management is so integral a component of forestry, that it is not easily separated as a distinct process within this discipline. Carter (1979) stated:

"In fact, when we single out forest weed control as a separate practice for a study of integrated pest management, we run the risk of defeating our purposes..."

While recognizing the importance of this point, the major emphasis of this chapter will involve discussing weed management as a tool for reducing competition to desirable crop trees from undesirable plants.

The purpose of weed management in forests is to arrest, reverse, or hasten plant succession for the enhancement of production of various goods and services from the forest (Stewart 1979). Professional foresters in the USDA-Forest Service and private industry view weed management as crucial to their ability to maintain adequate supplies of forest products in the face of increasing demand and a reduced land base (Society of American Foresters 1978). The USDA-Forest Service (1979a) projects that under base level prices, a negative supply-balance for softwoods will exist by 1990, and will increase at least through the year 2030 (Appendix Table-1). Imbalances are projected to be most severe in the South Central and Pacific Northwest Regions.

While intensive forest management, and therefore weed management, is viewed as an effective means to achieve increased timber yields, a considerable portion of forest land is managed less than intensively (Miller and Committee 1975). USDA-Forest Service data (1979a) indicate that national current annual growth for all types of ownerships is only 61 percent of potential annual growth (Appendix Table-2). The greatest difference between current and potential growth occurs on National Forest lands, where only 48 percent of the potential growth is being realized. Regional breakdowns indicate that the disparity is greatest in the Pacific Northwest, where actual growth on USDA-Forest Service lands is only 33 percent of the potential.

The need for weed management to achieve increased yield of forest products is obvious, but increasing timber yield is often secondary to other management objectives (Dierauff 1978). It is critical in weed management to define a plant "pest" only in terms of its relationship to management objectives. Weed management opportunities discussed herein include site preparation/stand conversion, release, thinning, and nurseries/seed orchards.

4.1 Site Preparation/Stand Conversion

Site preparation and stand conversion are used to give desirable vegetation a competitive advantage over pest plants. Site preparation can be accomplished using one or more of several methods. These are defined and described by the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979), Carter *et al.* (1978), Newton (1978), and others. They include chemical, mechanical, hand, prescribed fire, and combination methods.

Data from the USDA-Forest Service (Table 4-1) indicate that from 1973 to 1975, accomplished site preparation acreage increased, followed by a general decrease to date. This trend is uniform throughout Regions, except in Region 10, where considerably less site preparation has been accomplished. In a recent evaluation, the USDA-Forest Service (1978a) noted that target accomplishments for reforestation (of which site preparation is a part) are not being met. This deficiency is critical as a Congressional mandate exists for the completion of all backlog reforestation work by 1984 (90 Stat. 2949).

The use of site preparation is highly variable among Regions. Region 8 has the highest total accomplishment of 570,053 acres since 1973. Regions 9 (with 262,389 accomplished acres) 1 (249,354 acres), 5 (153,936 acres), and 6 (146,598 acres) follow (Table 4-1). A survey of private industry (American Paper Institute and National Forest Products Association 1978) showed that site preparation is even more extensive in private industry for the south (1,175,350 acres in 1977) and on the Pacific coast (167,750 acres). Data to evaluate effectiveness of site preparation has, in general, not been collected, except on the research level (USDA-Forest Service 1978a).

Chemical Site Preparation

A great deal of research has been committed to studies that describe the efficacy of chemicals and recommend application rates, methods of application, and proper choice of herbicide for site preparation (see, for example, Tarrant *et al.* 1973; Gratkowski 1978, 1975; McLemore 1977; Williams 1977; and Dimock *et al.* 1976). By categorizing titles or citations found in USDA-Forest Service (1979b, 1978b, 1977, 1976a, 1974a, 1972, 1971, 1970) annual research accomplishment reports, the number of publications regarding chemical methods of site preparation from 1970 through 1978 can be determined (Appendix Table-3). This number reflects the emphasis each reporting unit has placed upon chemical site preparation. Although there is a decline in publications since 1975, trends over time are relatively stable (Figure 4-1). This research emphasis is centered at the Pacific Northwest and Southern Experiment Stations (Table 4-2).

TABLE 4-1. Site preparation for planting, seeding, and natural regeneration (acres). Source: U. S. Forest Service, Washington Office, annual reforestation accomplishment reports, 1971-1979.

YEAR	REGIONS 1	2	3	4	5	6	8	9	10	TOTAL
1978	30,138	7,236	6,583	15,472	28,339	24,594	89,657	41,933	2,107	246,059
1977	25,685	18,197	6,379	13,516	23,796	22,626	81,479	30,854	798	223,330
1976 & TO	35,722	7,144	5,776	15,748	30,374	33,586	96,893	46,073	--	271,316
1975	43,792	13,753	8,888	19,092	29,622	26,048	103,006	47,601	80	291,882
1974	55,363	13,186	6,439	13,419	22,028	19,329	106,237	53,408	--	289,409
1973	58,654	12,418	1,464	9,762	19,777	20,415	92,781	42,520	32	257,823
TOTAL	249,354	71,934	35,529	87,009	153,936	146,598	570,053	262,389	3,017	1,579,819

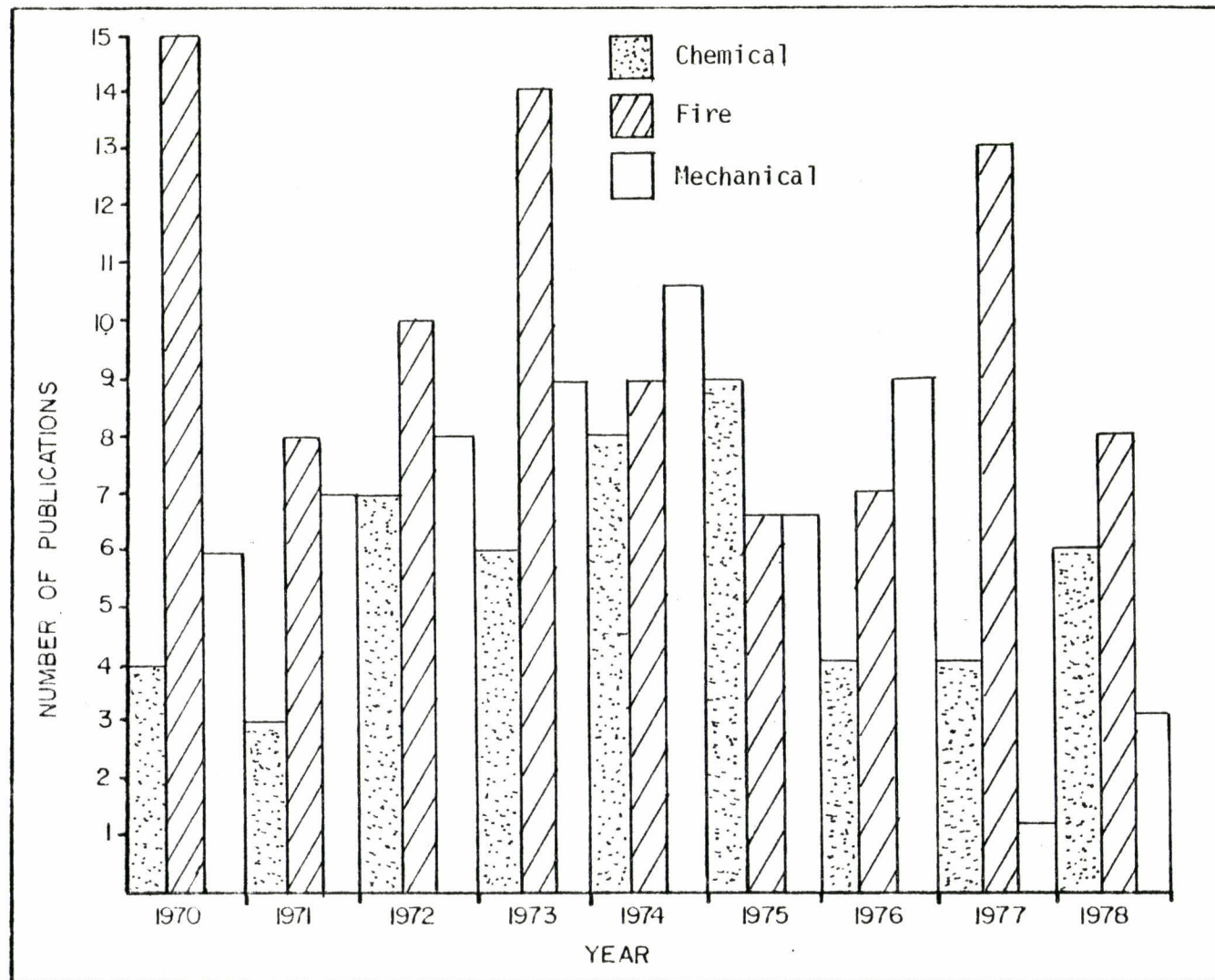


FIGURE 4-1. Annual site preparation methodology research.¹

¹Based on number of research publications listed in Forest Service annual research accomplishments. These methods comprise 95 percent or more of the reports which address site preparation methods.

TABLE 4-2. Site preparation methods research through Experiment Stations. ¹					
ESP. STN.	METHOD				Total
	Chemical	Fire	Mechanical	Hand	
INT	3	19	7	-	29
NE	0	1	3	-	4
NC	9	22	10	-	41
PNW	14	9	3	-	26
PSW	4	8	3	-	15
RM	1	3	3	-	7
SE	2	15	10	-	27
SO	15	4	19	-	38
FPL	-	-	-	-	-
WO	-	-	-	-	-
OTHER	3	8	1	-	12
TOTAL	51	89	59	-	199
¹ Based on the number of publications in Forest Service research accomplishment reports 1970-1978.					

The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) listed the most common herbicides used for site preparation and other practices (Appendix Table-4). Several authors discussed the advantages and disadvantages of chemical site preparation techniques. Williams (1977) noted that chemical application of herbicides can be conducted at a low cost and with minimal disturbance to the site. However, other cost estimates range from \$10-\$153 per acre (Stewart 1979). Carter et al. (1978) concurred that the relative low cost of herbicides make them advantageous for use in site preparation. Further, the authors noted that chemical methods are far less limited by topography than are other methods, especially mechanical and hand. In fact, because of the latter consideration, the authors stated, "The mountainous areas of the western United States are especially unsuited for these mechanical techniques..." Newton (1978) compared costs and impacts of alternatives and concluded that any of several chemicals may be used in preference to non-chemical methods in the interests of soil, water, and wildlife protection. Reasons for not favoring chemical techniques include weather restrictions, resistant species, lack of effect in some multi-layered stands, increased fire hazards, critical timing, limitations due to economies of scale, and environmental effects due to herbicides. The use of herbicides for site preparation has been favored by professional foresters due to practical and economic advantages, but has been restricted because of public concern and debate over possible health hazards from herbicides.

The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) estimated that 10 percent of total site preparation in the South and the Pacific Coast is accomplished using chemical means (Table 4-3). In the South, 5 percent was accomplished using 2,4,5-T, while on the Pacific Coast, 6 percent depended upon 2,4,5-T. The "North" (Region 9, portions of Regions 2 and 3) used herbicides in 2.5 percent of site preparation activities, with 0.5 percent accomplished using 2,4,5-T. The "Rocky Mountains" section (Forest Service Regions 3, 4, and portions of regions 1, 2) only depended on herbicides for 0.2 percent of site preparation activities, with no use of 2,4,5-T.

Prescribed Fire for Site Preparation

Although one of the major objectives of prescribed fire is the control of unwanted vegetation, Martin and Bell (1978) suggested that fire is also extremely useful in exposing mineral soil for regeneration and in disposing of residual slash. Fire as a site preparation tool has been used since the beginning of the century and has often proved to be the most practical method for site preparation (Jackson 1974, Mobley et al. 1977). USDA-Forest Service research continues on the uses of prescribed fire as a method of site preparation (Appendix Table-5). Several different

TABLE 4-3. Estimated proportion of use of weed management methods for site preparation and rehabilitation by section
(Source: USDA-States-EPA 2,4,5-T RPAR Assessment Team 1979).

Purpose and method	Proportion of use by section			
	North ¹	South ²	Rocky Mountains ³	Pacific Coast ⁴
	-----percent-----			
Site preparation				
2,4,5,-T	0.5	5	0	6
Other herbi-				
cides	2	5	0.2	4
Mechanical	26	28	45	24
Manual	65	1	20	4
Fire	6	9	35	32
Combination ⁵	-	53	-	30
Rehabilitation				
2,4,5-T	-	41	-	10
Other herbi-				
cides	-	48	-	12
Mechanical	-	9	-	62
Manual	-	-	-	2
Fire	-	0.4	-	13
Combination	-	1	-	1

¹The North section corresponds roughly to Forest Service Region 9, and portions of Regions 1 and 2. These data are based on a sample of National Forest Lands.

²The South section corresponds to Forest Service Region 8. These data are based on a sample of National Forest Lands.

³The Rocky Mountain section corresponds roughly to Forest Service Regions 3 and 4, as well as portions of Regions 1 and 2. These data are based on a sample of National Forest Lands.

⁴The Pacific Coast section corresponds roughly to Forest Service Regions 5 and 6. These data are based on a sample of National Forest and industrial forest lands.

⁵Use not reported in the northern section.

methods have been developed to initiate and manage prescribed fires which include: (a) methods of ignition; (b) spatial patterns of ignition; and (c) relationships of fire direction to wind direction (Mobley et al. 1977).

During the period 1970-1978, more papers have been consistently published on prescribed fire as a tool for site preparation than have been published for any other method (Figure 4-1). A high degree of variability prevents distinguishing trends over several years. Research has been centered at the North Central, Inter-mountain, and Southeastern Experiment Stations (Table 4-2).

However, Carter et al. (1978) described problems with using fire. First, on steep terrain, it is difficult to burn uniformly and to control the fire. Second, strong air pollution restrictions in Class I areas and air quality limited areas prohibit the use of fire in many instances. Third, extreme fire hazards exist when burning in summer, even though summer may be the best time for effective site preparation burns in some areas. Moreover, fire can also increase erosion and stimulate resprouting and germination of some brush species.

Detailed compilations have been prepared on the effects of fire on air (Sandberg et al. 1979), on soil (Wells et al. 1979), and fauna (Lyon et al. 1978). The impacts of fire on air and soil are continuing research programs of the USDA-Forest Service.

Within the National Forest System, fire is increasingly used as a site preparation tool, as measured both in total acres treated (Table 4-4), and as a percentage of total site preparation. In recent years the use of fire for site preparation has also expanded geographically; in 1977 and 1978, it was used in Regions 2, 3, 5, 6, and 10, whereas it was not used at all in those Regions in 1973-1976. By far the most extensive use of fire as a site preparation tool occurs in Region 8 (South) and, to a lesser extent, Region 9 (North). In the South, Jackson (1977) and Mobley (1974) estimated 2.8 million acres are burned by prescribed fire on all ownerships annually. Although the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) did not report a high degree of use of fire for site preparation, (Table 4-3) much of the use of "combination" treatments could involve fire.

Mechanical Site Preparation

In addition to managing vegetation, mechanical treatment serves to expose mineral soil and improve drainage on very wet sites (Balmer et al. 1976). Moreover, mechanical treatments can stimulate desirable coppice reproduction. Carter et al. (1978) suggested that mechanical treatment is, on occasion, the preferred alternative because these additional objectives are met.

TABLE 4-4. Site preparation by fire, as a percentage of total site preparation (Source: USDA-Forest Service, Washington Office reforestation annual accomplishment reports, 1971-1978).

YEAR	REGIONS									Combined Regions
	1	2	3	4	5	6	8	9	10	
1978	-	8.42	-	5.64	39.76	19.67	32.82	8.26	3.42	20.54
1977	-	27.49	2.59	0.50	-	23.37	27.90	16.77	-	17.21
1976 & TQ	-	-	-	-	-	-	7.04	0.14	-	2.54
1975	-	-	-	-	-	-	18.56	3.44	-	7.11
1974	-	-	-	0.48	-	-	21.35	3.15	-	8.44
1973	-	-	-	5.27	-	-	21.72	1.87	-	8.32
Combined years: Total %		7.80	0.46	1.74	7.32	6.91	21.21	4.86	2.39	10.29
Total Acres, site preparation by fire	5,612	165	1,518	11,266	10,124	120,912	12,818	72	162,487	

Mechanical site preparation can increase hazards from erosion, can cause soil compaction and rutting, is limited on steep slopes and on rocky ground, and can stimulate resprouting and seed germination of undesirable vegetation. Additionally, the capital intensive nature of mechanical site preparation make it available only to larger landowners (Carter et al. 1978). Compared to other alternatives, mechanical site preparation is energy intensive. Costs typically range from \$40-\$125 per acre (Stewart 1979).

Relative effort of USDA-Forest Service research on mechanical site preparation is summarized in Appendix Table-6. Although publications addressing mechanical site preparation increased from 1970 to 1974, they have decreased thereafter (Figure 4-1). Experiment Stations emphasizing this work include the Southern, Southeastern, North Central, and Intermountain (Table 4-2). The use of mechanical treatment for site preparation has been summarized by the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) (Table 4-3) and estimated for private industry by survey (American Paper Institute and National Forest Products Association 1978). In nearly all sections except the Rocky Mountains, mechanical treatment is responsible for roughly 25 percent of all site preparation. In the Rocky Mountains, the figure is considerably higher (45 percent; most of the timber management in this region occurs on the relatively flat canyon bottom). Private industry data showed mechanical treatment to be slightly less important. Trevison (1977) noted that mechanical site preparation is an important tool in the South, but cost has necessitated a gradual change from multiple treatments to single treatments.

Hand Methods for Site Preparation

While hand methods are often thought of as a viable method of site preparation by the public, most professional foresters believe that in many circumstances, the potential for hand control of vegetation as a site preparation technique is limited. Costs of hand methods for site preparation range from \$40-1,200 an acre, and hand methods are further limited by hazards to workers, effects that stimulate resprouting of vegetation, steep slopes, as well as the lack of available manpower. Roberts (1979) observed that cutting led to an increased density of brush. However, hand methods can be used on areas with herbicide resistant species; hand methods also use low amounts of energy, and their use can reduce unemployment.

Very little research on hand methods has been accomplished in recent years (Table 4-2). Perhaps this is because, unlike other methods, advanced technology is not required, so development does not require intensive research efforts. The USDA-Forest Service, however, has recently initiated several administrative studies to examine the viability of hand techniques. Further, numerous

studies of hand brush cutting were conducted and published up to the late 1950's when phenoxy herbicides became readily available.

Hand techniques are widely used in the North, where 65 percent of all site preparation is accomplished by hand, and in the Rocky Mountains, where 20 percent of the site preparation involves hand cutting (Table 4-3; USDA-States-EPA 2,4,5-T RPAR Assessment Team 1979). In contrast, only 1 percent of site preparation in the South is accomplished by hand, while on the Pacific Coast, the figure is 4 percent. Industry figures (American Paper Institute and National Forest Products Association 1978) bear out that hand methods are of little importance in the South (1%) and the Pacific Coast (0.6%).

Combination Techniques for Site Preparation

According to the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979), various combinations of mechanical/fire, chemical/fire, and chemical/mechanical treatments are used. Of special note is the combination of mechanical treatment, followed by fire, which is used in over half of all site preparation by private industry in the South, and 26 percent of all site preparation by private industry on the Pacific Coast. A second combination of note is that of chemical with fire. In general, the herbicide serves to desiccate vegetation, so that burning is easier under adverse conditions (Green 1977, Stewart 1978). In the West, where site preparation occurs on extensive brushfields, Dimock *et al.* (1976) found that combining herbicides with mechanical means and/or fire is a very successful method.

Alternative Techniques for Site Preparation; Grazing and Other Biological Methods

Although grazing has been thought of as a weed management tool on rangelands (Vallentine 1971) and fuelbreaks (Green 1977), very little consideration has been given to it as a method for site preparation. Because of certain drawbacks, the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) stated, "Where vegetation is well established, the grazing intensity needed to prepare a site...in a responsible time period may result in compaction or stream contamination."

Admittedly, much of the feeling towards grazing is negative, possibly due in large part to exploitative grazing practices at the turn of the century. Spurr and Barnes (1973) felt that where grazing is used to alter vegetation, changes are more likely to be for the worse than for the better. Further, they stated that grazing tends to stimulate woody brush, compact the soil, reduce soil aeration and water infiltration, increase the potential for erosion, and degrade local water quality with livestock manure.

Very little use of any other biological control is evident. The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) reported that several factors strongly limit the usefulness of biological control agents, including: (a) repeated defoliation or killing of resprouting stems in successive years is needed to produce adequate control, (b) life cycles and mass rearing methods for any potential organisms are largely unknown, and (c) proper timing, intensity, and distribution of outbreaks and confinement of effects to the treated areas are difficult to achieve. Very little research emphasis is evident in the field of biological control of weeds which interfere with timber production (Table 4-2).

Effects of Other Forest Management Practices on Site Preparation

If the "weeds" controlled during site preparation were to become useable, it would be much more economical to use labor and/or capital intensive techniques for harvest rather than to use inexpensive methods for control. Green (1977), for example, stated:

"...the slow progress and high costs probably will always prohibit use of hand clearing operations on extensive acreages of wildlands in California. A radical change might occur, however, if using the "waste" woody material as an energy source becomes feasible." (Emphasis added).

Research in the area of increased utilization of forest products has been extensive in the USDA-Forest Service. Although this has involved finding uses for species often considered as weeds, such as red alder and aspen, the economic value of these species is still somewhat limited.

A second modification, reported by Newton (1973) and the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979), is the use of hardier stock and/or more shade-tolerant species for planting. Further, the Team noted the possibility of using desirable species to limit establishment of competitors and regulation of overstory density to reduce vigor of understory species. However, the Team further noted that these methods "are not widely used at present because of a lack of basic ecological information about the major commercial tree species and their competitors."

Summary

Although site preparation accomplishments in the USDA-Forest Service have been highly variable during the years 1973-1978, no long-term increases or declines are evident. Site preparation can be accomplished using one or more of several methods which include chemical, mechanical, hand, prescribed fire, and combination methods.

The use of chemical herbicides for site preparation is most important in the South (R-8), and on the Pacific Coast (R-5 and 6), where they are used in approximately 10 percent of all site preparation, and considerably more for stand conversion (rehabilitation). Research on herbicides for site preparation is concentrated in corresponding Experiment Stations; namely the Pacific Northwest and the Southern Stations.

Perhaps the most prevalent tool for site preparation is prescribed fire, which is used alone or in combination with chemical herbicides and/or mechanical techniques. It is especially prevalent in R-8, but is being used increasingly in all Regions. Research has been more prolific on fire as a site preparation tool than any other method, and has been a significant endeavor at the North Central, Intermountain, and Southeastern Experiment Stations.

Mechanical methods are uniformly used in approximately one fourth of all site preparation, except in Regions 3 and 4, where it accounts for almost half of the treated acreage. Research has been variable during the period 1970-1978, but centered at the Southern, Southeastern, and North Central Stations.

Manual methods are used significantly in Regions 9, 3, and 4, but very little research in recent years has addressed them. Biological methods are not used, but various combinations of mechanical/fire, chemical/fire, and chemical/mechanical are employed.

The use of site preparation is influenced by harvest technique, planned reforestation methods, and the ability to utilize residue. Effective use of site preparation can reduce the need for other weed management treatments for several years in the development of a stand.

4.2 Release

Release operations are those procedures applied in very young stands with the intention of freeing desirable tree species from "weed" species.

Data portrayed in Table 4-5 indicate that release and weeding accomplishments in the Forest Service have been variable, with a generally stable trend evident between 1971 and 1978. Nationally, the Forest Service has averaged approximately 113,420 treated acres annually during that time.

Regions where the greatest amounts of release have been accomplished include Region 9 (321,260 acres), 8 (228,685 acres), 6 (160,694 acres), and 5 (106,173). In Region 9 an increase in release and weeding occurred in 1973, followed by a decrease to 1975, and increases thereafter. Release and weeding declined in

TABLE 4-5. Annual reforestation and timber stand improvement. Release and weeding (acres).
(Source: USDA-Forest Service, Timber Management Annual Accomplishment Reports)

	REGIONS									
YEAR	1	2	3	4	5	6	8	9	10	TOTAL
1978	3,554	6,746	496	4,685	8,441	15,583	33,507	37,584	133	110,729
1977	3,600	8,145	215	4,324	9,754	10,612	29,851	35,963	-	102,464
1976 & TQ	3,577	3,467	170	4,908	33,310	26,469	25,438	38,004	-	135,343
1975	3,296	4,268	40	1,835	19,744	31,985	20,851	33,755	-	115,774
1974	4,708	2,873	63	1,586	2,241	19,306	23,741	39,392	-	93,910
1973	3,772	2,824	206	1,237	1,817	27,605	27,311	51,744	-	116,516
1972	5,021	2,049	65	2,651	14,332	10,614	31,443	46,698	-	112,873
1971	4,053	944	1,848	3,191	16,534	18,520	36,543	38,120	-	119,753
TOTAL	31,581	31,316	3,103	24,417	106,173	160,694	228,685	321,260	133	907,362

Region 8 to 1975, but has increased since. In Region 6, release and weeding increased to 1975, but decreased dramatically since. Trends in Region 5 are similar to those of Region 6.

Available methods for release include chemical, either broadcast or selective application, prescribed fire, and hand techniques. Mechanical means are not considered an alternative, since it is not possible to select between desired crop trees and unwanted vegetation with the use of machinery (Lawrence and Walstad 1978). Nearly 60 percent (Table 4-7) of herbicide use in forestry is due to chemical release methods. In Oregon and Washington, (R-6) almost all release is done with herbicides.

With the use of herbicides in forestry becoming highly controversial, release as a necessary practice is being questioned. Groundwork, Inc., a private, forest workers research group, has been conducting studies on a release project on the Willamette National Forest in Oregon (Groundwork, Inc. 1978). The studies focus on units of the Willamette which were scheduled to be sprayed with 2,4,5-T in 1978. A change in Forest Service policy (required the approval of USDA Assistant Secretary for Natural Resources and Environment before 2,4,5-T could be used) effectively ended spraying after only a few of the areas scheduled for treatment had been sprayed. Groundwork, Inc. Project Leader, Howard Horowitz, feels the data collected on the Willamette indicate that much of the area which was scheduled for spraying did not require release because many of the crop trees had already topped the brush (Horowitz 1979, personal communication). Comparison of 2-year tree leader growth on sprayed and unsprayed areas showed that growth in many of the unsprayed areas equalled the leader growth in the treated units. Even though this study has yet to be completed, published, and thoroughly corroborated, it questions the benefits of existing Forest Service release practices.

The Forest Service's concern over release is evident in a recent evaluation of timber stand improvement, which includes release along with precommercial thinning (USDA-Forest Service 1978a). The Forest Service noted that even with the use of release, target accomplishments are not being met. This shortcoming is of concern in light of the legal mandate to complete all backlogged work by 1984. Very little information is available that enables evaluation of the success of these release projects (USDA-Forest Service 1978a).

Chemical Release

Lawrence and Walstad (1978) reported, "Today, aerial and ground application of herbicides has generally proven to be the most effective method (for release)." Research since the mid 1940's has led to the development of herbicides which are very effective on "weed" species while not harming desired crop trees.

Stewart (1979) described advantages of both broadcast (aerial spray), and selective (hand injection) techniques. Advantages of aerial spray include: (a) large acreages can be covered with a small crew, (b) costs per acre are low (\$10-\$75 per acre), and (c) application is not limited by terrain. Disadvantages are (a) weather restrictions, (b) resistant pest species, (c) economies of scale, (d) critical nature of application timing, (e) increased fire hazard, (f) ecological impact to non-target areas caused by herbicide drift and vaporization. A disadvantage of herbicides not listed by Stewart is potential impact on non-target species, including humans, that are in the treated areas either during or after treatment. Gratkowski (in press) observed that Douglas-fir released from Ceanothus by hand clearing or chemical treatment showed the chemical treatment to be more successful. The difference was significant by the fifth year, and increased thereafter.

In addition, the use of aerial spraying of herbicides for release brings with it the same public concern associated with chemical techniques in general. Indeed, these concerns, if anything, are more strongly evident, since the use of herbicides for release is much more extensive than is herbicide use for site preparation.

The advantages listed by Stewart (1979) for selective methods (hand injection) include (a) inherent selectivity of the technique, (b) low energy use, and (c) ability to provide employment. Disadvantages are (a) terrain limitations, (b) increased fire hazard, (c) limited amount of available manpower, and (d) critical nature of application timing. Injection also places the applicator in intimate contact with concentrated chemicals. Thus far, the users appear to sustain low rates of exposure (Newton 1979, personal communication).

Examination of research publications reveals that the study of chemicals for release purposes is a very significant program of the Forest Service (Appendix Table-7). Research included determination of dose rates, proper timing, and application techniques. A significant amount of this research was accomplished by the Pacific Northwest Experiment Station (Table 4-6), as evidenced by Crouch and Hafenstein (1977); Gratkowski (1974, 1975, 1976, 1978); and Stewart (1976). The Southern Experiment Station has also emphasized this research.

TABLE 4-6. Release methods research through Experiment Stations. ¹				
EXP. STN.	METHOD			
	Chemical	Fire	Hand	Total
INT	-	8	-	8
NE	2	1	-	3
NC	4	19	-	23
PNW	22	5	-	27
PSW	2	6	-	8
RM	-	-	-	-
SE	1	19	-	20
SO	18	11	-	29
FPL	-	-	-	-
WO	1	-	-	1
OTHER	0	7	-	7
TOTAL	50	76	-	126
¹ Based on number of research publications in Forest Service annual research accomplishment reports. These publications comprise 95 percent or more of research publications addressing alternative release methods.				

TABLE 4-7. USDA-FOREST SERVICE USE OF HERBICIDES FY 76	
Kinds of Uses (Source: Witt 1978)	
<u>Description</u>	<u>Percent of use</u>
Release	59.3
Site Preparation	12.3
Right-of-way	11.8
Range Rehabilitation	5.5
Thinning	3.6
Aquatic	2.2
Fuel Breaks	1.6
Noxious Weeds	1.3
General Weeds	1.0
Wildlife Management	0.9

Publications of relevant papers seemed to increase with 1974, and decline thereafter (Figure 4-2). Research on chemicals, however, has been secondary to research on prescribed fire.

Use of herbicides for release is extensive. Witt (1978) reported that in FY 76, by far most of the herbicide used by the USDA-Forest Service occurred to accomplish release objectives (Table 4-7).

The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) estimated the use of chemicals for release and timber stand improvement (TSI) relative to other methods (Table 4-8). The Pacific Coast (Regions 5 and 6) relies on chemical means to the highest extent, with 63 percent of all release and TSI work accomplished by chemicals. However, if release is considered separately, approximately 98 percent of all acres treated on the Pacific Coast were accomplished chemically. In the South (Region 8), herbicide methods are used in 34 percent of all release and TSI projects. In the North (Region 9, portions of Regions 1 and 2), herbicides are used for 39 percent of the release and TSI, while in the Rocky Mountains, (Regions 3, 4 portions of 1, 2) only 0.6 percent of all release and TSI is accomplished through chemical means. Interestingly, over 75 percent of all chemicals used for release on the Pacific Coast consisted of 2,4,5-T prior to its ban by the U. S. Environmental Protection Agency.

Prescribed Fire for Release

Mobley et al. (1974) stated that prescribed fire can be used very effectively to manage undesirable hardwoods. In the strict sense, it is difficult to view prescribed fire in existing stands as a tool for "release." By definition, release is a practice accomplished in young stands, when fire would destroy not only the unwanted vegetation, but the crop trees as well. Carter et al. (1978) reported that, for southern pines, prescribed fire is useful only after the stand has reached 10-15 years of age. Mobley (1974) stated that southern pines should be at least 4 inches d.b.h. before prescribed burning.

Stewart (1979) reported the cost of prescribed fire for release as low, \$3-\$71 per acre. He described other advantages as: (a) fire hazard reduction, and (b) relatively few terrain limitations. Disadvantages included: (a) lack of selectivity, (b) suitability for only a few conifer species, (c) existence of weather restriction, (d) increased air pollution, and (e) increased erosion hazard. In recent years, air pollution effects have become a significant factor. Of note are Class I areas, where no degradation of air quality is permitted, and air quality limited areas, where pollution is already higher than normal.

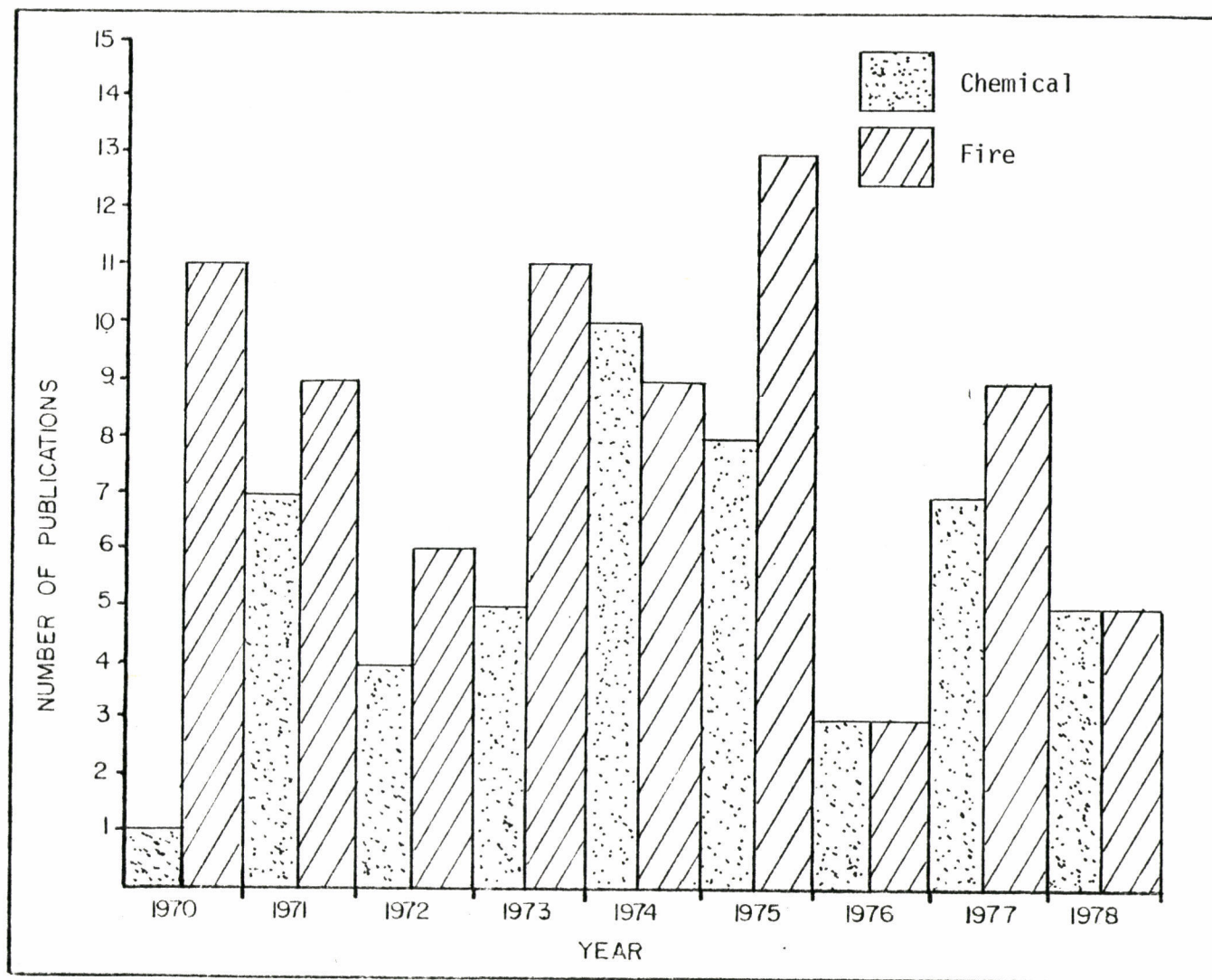


FIGURE 4-2. Annual release method research.¹

¹Based on number of research publications in Forest Service annual research accomplishment reports. These publications comprise 95 percent or more of the research publications which address alternative release methods.

TABLE 4-8. Estimated proportion of use of weed management methods for release and TSI by section (Source: USDA-States-EPA 2,4,5-T RPAR Assessment Team 1979).

METHOD	Proportion of use by section			
	North ¹	South ²	Rocky Mountains ³	Pacific Coast ⁴
	-----percent-----			
2,4,5-T	6	20	0.1	49
Other herbi- cides	33	14	0.5	14
Mechanical	0	0.4	0	trace
Manual	61	0.1	99	37
Fire	0	65	0	0
Combination	0	0	0	0

¹The North section corresponds roughly to Forest Service Region 9, and portions of Regions 1 and 2. These data are based on a sample of National Forest Lands.

²The South section corresponds to Forest Service Region 8. These data are based on a sample of National Forest Lands.

³The Rocky Mountain section corresponds roughly to Forest Service Regions 3 and 4, as well as portions of Regions 1 and 2. These data are based on a sample of National Forest Lands.

⁴The Pacific Coast section corresponds roughly to Forest Service Regions 5 and 6. These data are based on a sample of National Forest and industrial forest lands.

Research on the use of prescribed fire, and the role of fire in natural and man-dominated ecosystems has been extensive (Appendix Table-8). Research on the use of prescribed fire for weed management in established stands has centered in the Southeastern, North Central, and Southern Experiment Stations (Table 4-6). Other stations engaged in this work include the Intermountain, Pacific Northwest, and Pacific Southwest (Clark 1979, personal communication). During the period 1970-1978, research on prescribed fire was greater than that for release (Figure 4-2). Publications increased to 1975, and declined thereafter.

The most extensive use of prescribed fire for weed management in established stands occurs in Region 8, with lesser amounts occurring in Regions 2, 4, 5, and 9 (Table 4-9). During the period 1973-1978, a general increase in prescribed burning occurred, ranging from 16,294 acres in 1973 to 50,688 acres in 1978. This increase is due to greater use of fire in Region 8, and to the expanding use of fire in other Regions. The feeling that prescribed fire is used extensively in the South is corroborated by the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979; Table 4-8).

Hand Techniques for Release

Although highly acclaimed in some portions of the public sector, the use of hand labor for release has been declining in importance. Van Strum (1978), for example, summarized the views of a portion of the public:

"The best fertilizer is the shadow of the grower. These sites are visited rarely. People that live in these areas see them every day. There are sites that can only be logged selectively and need people examining, working, walking.

"I think we should try to see what can be done putting that kind of money, the type of money now spent on herbicide management which moves throughout the whole cycle, people who stay with the work because it is well paid (sic); they enjoy the work; it is good work; it is necessary work."

"There is a labor force to do it, certainly in the cost range. There is high employment. There are people who love this work." (Emphasis added).

On the other hand, much sentiment exists in the professional forestry community which opposes manual release methods (Carter et al. 1978, Lawrence and Walstad 1978). Disadvantages are: (a) high cost (\$40-\$1200 per acre), (b) stimulation of resprouting, (c)

TABLE 4-9. Burning to control understory vegetation (acres). Source: U.S.D.A. Forest Service, Washington Office Timber Management accomplishment reports.

	REGIONS									
YEAR	1	2	3	4	5	6	8	9	10	TOTAL
1978	-	1,200	-	550	1,914	-	47,024	-	-	50,688
1977	-	10,687	-	-	980	-	43,300	-	-	54,967
1976 & 1Q	-	2,420	-	-	610	-	35,144	40	-	38,214
1975	-	-	-	-	154	-	6,295	-	-	6,449
1974	-	-	-	-	47	-	19,672	-	-	19,719
1973	-	-	-	-	-	-	16,294	-	-	16,294
										-
										-
TOTAL	-	14,307	-	550	3,705	-	167,729	40	-	186,331

increased fire hazard, (d) limitations of terrain, (e) hazards to workers, and (f) lack of availability of workers. Advantages of manual release include: (a) methods are useable on areas with herbicide resistant species, (b) low energy use, (c) reduced unemployment, and (d) selective treatment (Stewart 1979).

While little research in the area of hand methods for release has been undertaken in recent years (Table 4-6), a good data base exists from earlier research (Clark 1979, personal communication). Due to the interest of the public and some government agencies, a series of studies have been instituted by the Josephine County Forestry Department in the Siskiyou Mountains of Western Oregon (Bernstein 1978, Bernstein and Brown 1977). These initial studies measured cost of treatment, damage to desired conifers, percent release, hazards to workers, and worker attitudes. Costs were comparable to those stated above, while an average of 31 percent of the conifer seedlings were damaged or covered by slash during the operation; 56 percent of the seedlings were classified as released. Hazards to workers were found to be higher than those encountered during precommercial thinning, and increased absenteeism indicated unfavorable worker attitudes toward the project. Followup studies through the third growing season indicated that resprouting was responsible for the crown closure of brush to return to an average of 60 percent of its previous value (Bernstein 1979). The author described manual methods for release as possibly having marginal merit. These studies have been called into question by those who feel that by using insufficiently skilled labor (CETA workers), the studies were not able to document the potentially positive effects which would have occurred if professional woods workers had been used (Horowitz 1979, personal communication).

Roberts (1979) conducted similar studies on different plots in Oregon, and found brush sprouting after cutting to be vigorous. Height of brush after resprouting ranged from 2-4 feet, with some stems as tall as 12 feet. Number of stems increased from 2-10 times. Approximately 22 percent of the desired conifer trees were damaged by the operation. Similar studies were started in the South during the spring of 1979, but data from the first growing season has not yet been compiled or analyzed (Michael 1979, personal communication).

The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) reported that manual methods (Table 4-8) of release and TSI (the reader should be cautioned that these figures apply to both release and TSI) are responsible for 99 percent of the release and TSI efforts in the Rocky Mountain Region (Forest Service Regions 3, 4, and portions of 1, 2). In the North (Region 9, portions of Regions 1, 2) 61 percent of release and TSI work is accomplished by manual means. The degree of emphasis drops sharply on the Pacific Coast

(Regions 5, 6) to 37 percent, and in the South (Region 8) to 0.1 percent.

Combination Methods for Release

The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) indicated that combination techniques are not used for release and TSI purposes.

Alternative Techniques for Release: Grazing and Other Biological Methods

At present, grazing on forest land is practiced to some extent on National Forest lands. This occurs in young stands (transitory range), and in mature forests where an understory of forage serves as a range resource. The latter practice is especially common in Region 8, where much of the available range land is the understory of established southern pine stands. However, this practice is not reported as "weed management," but rather considered as the management of the range resource (Gillespie 1979, personal communication).

Feelings are mixed both within the USDA-Forest Service and on the outside, regarding the beneficial and adverse effects of grazing forest land. One of the major problems seen by some in the Forest Service is the lack of selectivity of livestock, which has caused often severe (at least in Regions 4, 6, and 8) damage to young plantations (USDA-Forest Service 1978a). Other harmful effects include stimulation of woody brush, soil compaction, adverse soil/water impacts, and degradation of water quality (Spurr and Barnes 1973). Some evidence suggests that the overall impacts are negative to the timber resource (Black and Vladimiroff 1963). Williston (1979, personal communication) stated that needed grazing management devices, such as fences, are too expensive to make increased forest grazing a viable option.

On the other hand, there is substantial feeling that these adverse impacts are realized not because grazing in itself is a poor management practice, but because it is a tool which can be easily misused. Proponents, such as Lewis (1974), and Pearson (1974), felt that not only could forest grazing provide extensive as yet untapped range resources, but that properly managed livestock could reduce the level of competing vegetation. Although some management recommendations have been made, such as reducing both tree and livestock stocking to obtain maximum total output, efforts to develop grazing as a weed management technique on forest land have been minimal when compared to the work accomplished on other techniques.

In the same vein, very little effort has been put into developing other biological controls specific to controlling undesirable vegetation in established stands (Table 4-6). The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) reported that the technology for these techniques does not exist, and would be difficult to develop. At present, therefore, there are virtually no programs on National Forests to use any biological control agents, other than grazing, to control weeds on established timber stands.

Effects of Other Forest Management Practices on Release

Increased potential for utilizing "waste" material, and alternative choices of seed, seedling stock, and species, can reduce the need for release, besides affecting site preparation needs.

Smith (1962) considered site preparation to be a crucial factor in determining future needs for release, and other operations. Where site preparation has eliminated competing vegetation and hampered resprouting, the need for release will be lessened, especially when compared to situations where site preparation served only to stimulate new sprouting.

Finally, both the time lag between site preparation and planting, and the form of regeneration can greatly influence the amount of weed control needed for later release. When regeneration is accomplished promptly after planting, maximum benefits are derived from prior weed management activities. If, however, regeneration is delayed, competing vegetation will have had an opportunity to gain a foothold, making release all the more necessary and intensive.

Summary

Release accomplishments have varied from year to year; some Regions have experienced dramatic declines in acres released. These include Regions 5 and 6. In Region 6, this decline occurred between 1976 and 1977, concurrent with controversies surrounding the Regional EIS on vegetation management with herbicides. Generally, release accomplishments are not meeting targets.

Herbicides are highly significant to release practices: 1) a significant percentage of the acres released are accomplished chemically, and 2) release accounts for approximately 60 percent of Forest Service herbicide use. Chemical methods are used extensively in Regions 6 and 8, and are also significant in Regions 9 and 5. While research on herbicides for release has been a significant activity of the Forest Service, recent declines are evident. This research has been most conspicuous at the Pacific Northwest and Southern Experiment Stations.

While prescribed fire is used to control species composition in existing stands, it is debatable whether or not, this is properly termed release. However, fire is used extensively in Region 8, and is gaining favor in other Regions (2, 4, 5). Research on fire has been extensive, and emphasized at the Southeastern, North Central, and Southern Experiment Stations.

Hand techniques recently have been publicized highly as an alternative to herbicides. However, the utility of manual release is hotly debated. Manual methods are used significantly in Region 9, but are not used as extensively in other Regions. Although past research has been done on manual methods, very little new research updates the state-of-the-art. However, research efforts on manual control are intensifying.

Combination and biological techniques are not used for release. Effective site preparation and regeneration techniques can reduce the need for release.

4.3 Thinning

Smith (1962) defined thinning as cuttings made in immature stands in order to stimulate the growth of the residual trees and to increase the total yield of useful material from the stand, in other words, concentrating the potential wood production of the stand on a limited number of selected trees. This section will consider primarily data available for precommercial thinning.

In the Forest Service, precommercial thinning falls under timber stand improvement. USDA-Forest Service accomplishment reports (Table 4-10) reveal that annual precommercial thinning has generally increased on a National scale, only partially offset by a sharp decrease in 1976. This same pattern is evident Nationally, for all Regions except Region 10, which shows the least acres accomplished of all Regions.

Regions with the greatest extent of precommercial thinning include Region 3 (a total, 1971-1978, of 536,276 acres), Region 6 (434,138 acres), and Region 1 (241,876 acres). Following are Region 8 (193,551 acres), Region 5 (184,560 acres), Region 2 (121,751 acres), Region 9 (106,671 acres), Region 4 (75,494 acres), and Region 10 (5,021 acres). While quantification of the amount of thinning is possible, determining its effectiveness is difficult with the available data (USDA-Forest Service 1978a).

Alternative methods for accomplishment of precommercial thinning and TSI include chemical treatment using selective hand injection, the use of mechanical treatment, and hand cutting. Additionally, the American Paper Institute and National Forest Products Association (1978) considered prescribed fire and the use of broadcast

TABLE 4-10. Annual reforestation and timber stand improvement. Precommercial thinning (acres).
(Source: USDA-Forest Service, Timber Management Accomplishment Reports)

YEAR	REGIONS									
	1	2	3	4	5	6	8	9	10	TOTAL
1978	21,605	24,479	90,807	17,504	23,515	69,033	31,746	29,224	2,330	310,243
1977	21,918	25,190	91,725	15,664	23,831	49,134	23,280	18,132	2,168	271,042
1976 & TQ	8,896	1,290	15,089	5,914	8,710	32,674	5,160	1,175	300	79,208
1975	40,363	23,305	99,908	11,654	33,741	73,361	30,447	10,191	223	323,193
1974	37,296	17,186	69,828	7,623	31,392	45,474	29,064	14,065	-	251,928
1973	33,141	14,666	62,123	3,630	22,668	56,885	28,594	12,146	-	233,853
1972	44,647	9,083	58,804	6,624	22,601	61,692	32,248	12,544	-	248,243
1971	34,010	6,552	47,992	6,881	18,102	45,885	13,012	9,194	-	181,628
TOTAL	241,876	121,751	536,276	75,494	184,560	434,138	193,551	106,671	5,021	1,899,338

herbicides to be appropriate timber stand improvement methods (for descriptions of these methods, see Section 4.2).

Chemical Treatment for Precommercial Thinning

Since the use of broadcast herbicides was discussed under release, this section contains data on selective methods for thinning. The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) listed the most often used herbicides for thinning, and describes their properties (Appendix Table-4). Costs of hand injection as a precommercial thinning method range from \$10-75 per acre. Advantages of hand injection include: (a) selectivity of treatment, (b) low energy use and (c) unemployment reduction. Disadvantages are: (a) hazards to workers, (b) limits due to topography, (c) limits due to availability of workers, (d) critical nature of application timing, and (e) increased fire hazards (Stewart 1979).

Witt (1978) reported that, in the USDA-Forest Service, the use of herbicides for thinning is comparatively minor to other herbicide uses. In 1976, only 3.6 percent of all herbicides used in the Forest Service were applied as thinning treatments (Table 4-7). Research on this method (Appendix Table-9), which has centered at the Southern Experiment Station (Table 4-11), has been low, but comparable to that for mechanical methods, and quite variable over the period 1970-1978 (Figure 4-3).

Mechanical Thinning

Use of mechanical means for precommercial thinning is restricted to areas where regularly spaced strips are cleared and no selection of leave trees is required (USDA-States-EPA 2,4,5-T RPAR Assessment Team 1979). Costs of mechanical thinning range from \$15 to \$175. The major advantage is that areas with herbicide-resistant species can be treated. Disadvantages include: (a) terrain limitations, (b) creation of erosion hazards, (c) soil compaction and rutting, (d) lack of selectivity, and (e) increased fire hazard.

Research on mechanical thinning (Appendix Table-10) has been concentrated at the Southern and North Central Forest Experiment Stations (Table 4-11). Due to the flat or gently sloping terrain of the South, mechanical thinning is perhaps more applicable there than in other, steeper areas (Jones 1974, Williams 1974). The number of publications have been variable during the period 1970-1978, and comparable to trends evident for chemical methods (Figure 4-3).

TABLE 4-11. Thinning methods research at Experiment Station. ¹					
EXP. STN.	METHOD				
	Chemical	Mechanical	Hand	Combination	Total
INT	2	1	-	-	3
NE	2	-	-	-	2
NC	-	6	-	-	6
PNW	3	2	-	-	5
PSW	1	1	-	-	2
RM	-	-	-	-	-
SE	2	4	-	-	6
SO	10	11	-	-	21
FPL	-	-	-	-	-
WO	-	-	-	-	-
OTHER	-	2	-	-	2
TOTAL	20	27	-	-	47
¹ Based on the number of research publications in Forest Service annual accomplishment reports 1970-1978. These publications comprise 95 percent or more of the research publications addressing alternative thinning methods.					

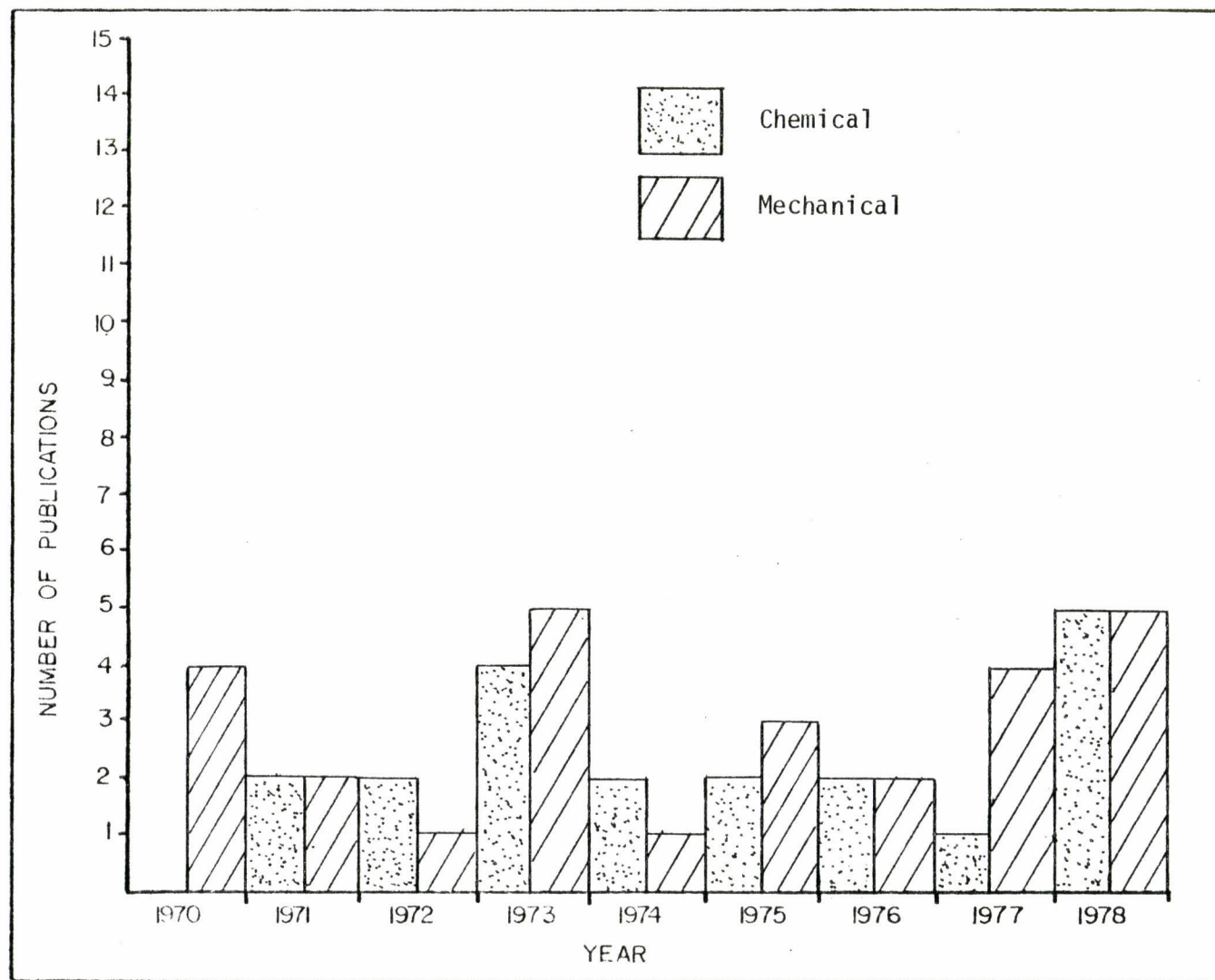


FIGURE 4-3. Annual thinning methods research.¹

¹Based on number of research publications in Forest Service annual research accomplishment reports. These publications comprise 95 percent or more of the research publications addressing alternative thinning methods.

Hand Methods for Precommercial Thinning

Using hand methods, unwanted trees can be removed by cutting with an ax or chain saw, or girdling layers around the tree. The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) considered manual methods as viable options in precommercial thinning. Costs of manual methods are estimated to range from \$50 to \$80 per acre (Clark 1979, personal communication). Stewart (1979) listed advantages that include: (a) selectivity of treatment, (b) low energy use, and (c) decreased unemployment. Disadvantages include: (a) hazards to workers, (b) limits due to terrain, (c) limits due to available labor supply and (d) increased fire hazard.

While very little research has been specifically concerned with development of hand thinning techniques, a great deal of energy has been expended determining the general effects of thinning on tree growth. Considerably less development of "high technology" is needed to develop hand methods, when compared to chemical or mechanical means.

Very few data are available to compare the extent of use of hand methods to other methods, to describe the use of hand methods on a regional level, or to chart changes over time. It is estimated, however, that manual control comprises a significant portion of all precommercial thinning throughout the country.

Combination Methods for Thinning

Initial mechanical thinning is often combined with hand or chemical thinning at a later date. Mechanical thinning serves to reduce extremely dense, young stands, while the other methods enable greater selectivity at later stages (USDA-States-EPA 2,4,5-T RPAR Assessment Team 1979).

Effects of Other Forest Management Practices on Thinning

Much of the need for thinning is determined by the manager's choice of regeneration technique. The stand density of crop trees can be controlled to a great degree if a stand is planted, and to a lesser extent if it is seeded. In planting, therefore, any need for thinning could partially be reduced by planting at wider spacings. With natural regeneration, however, the manager is less able to control spacing, possibly resulting in increased needs for thinning at later stages. These considerations should be balanced by the advantages of closer spacing, which include: increased ability to obtain more uniform stocking after thinning, more rapid natural pruning, and greater competitive advantage of the crop species.

The size of opening in the forest to be regenerated also can influence the future need for thinning. For example, natural regeneration from seed produced by the stand around smaller openings may require thinning even in widely spaced plantations.

Finally, increased use of small trees could change what would have been precommercial thinning operations into commercial thinning. As a result, at least a portion of the costs could be absorbed by the operation itself.

Summary

USDA-Forest Service accomplishments in precommercial thinning have generally increased over the period 1971-1978, with nearly two-thirds of all thinning done in Regions 3, 6, and 1. Region 8 accomplished roughly a third as much thinning as Region 3 during that period. However, the Southern and Southeastern Experiment Stations published over 57 percent (44 and 13 percent respectively) research on thinning methods. The Southern Experiment Station has emphasized research on chemical and mechanical methods for thinning. The use of chemical herbicides for thinning is small and accounts for only 3.6 percent of Forest Service herbicide use. Combination treatments often involve initial mechanical operations in very young stands, followed by more selective chemical and/or hand treatments at a later time. Effective regeneration techniques and ability to utilize thinned material are factors which can influence the need for thinning. While no research publications specifically address manual methods, these techniques are used extensively throughout the Forest Service.

4.4 Nursery and Seed Orchards

Miller and Committee (1975) characterized weed management on seed orchards and on nurseries as extremely intensive. However, the authors noted that acreage involved in these operations is quite small. In 1974, seed orchards comprised 9,263 acres nationwide, while nurseries were found on only about 9,000 acres.

For seed orchards, Miller and Committee (1975) described weed control practices:

"Weed control programs involve conventional tillage in preparation for planting, application of triazine herbicides during the first 1 to 3 years of growth, and mowing thereafter. There is no need for additional weed management tools."

On the other hand, nursery weed management has evolved considerably during very recent times. A great deal of effort has been spent, initially through Auburn University and later in research projects on the Pacific Coast, to develop herbicides for nursery use (Gjersted et al. n.d.). In addition, the concept of inte-

grated weed management has been adapted to the management of southern pine nurseries. While hand weeding has been de-emphasized, further developments have fostered mechanical, chemical, and biological (geese/hog grazing and competition from cover crops) techniques, and promoted increased sanitation of nursery areas. In the development of chemical techniques, the importance of using several herbicides, rather than one or two, has been stressed, in order to limit the development of herbicide-resistant species. Herbicides with potential for nursery-related use (including those not currently registered) are diclofop, napropamide, diphenamid, oxyfluorfen, mineral spirits, bifenox, methyl bromide, EPTC, trifluralin, oxadiazon, butylate, cyanazine, alachlor, metolachlor, fluchloralin, profluralin, vernolate, propazine, atrazine, glyphosphate, hexazonone, diuron, and simazine (South 1978).

SUMMARY

Weed management is used to arrest, reverse, or hasten plant succession for enhancing production of various goods and services from the forest. Activities involving weed management include site preparation or stand conversion, release, and thinning. The Forest Service has expressed the concern that accomplishment of these activities has been falling short of targets. Very few project evaluations are available which permit appraisal of the success of these activities.

Methods for accomplishing weed management include the use of herbicides, prescribed fire, heavy machinery, and hand labor. Biological control mechanisms are not well developed for weed control in timber management. Combination methods are used a great deal for site preparation, but are much less common in release, and thinning projects.

Development and use of herbicides are especially evident in the South (R-8, Southern Experiment Station), where intensive use of several techniques has become part of the highly-developed practice of managing southern pines, and on the Pacific Coast (R-6, Pacific Northwest Experiment Station), where steep terrain strongly limits other alternatives. Release is by far the most prevalent activity for which herbicides are used in the Forest Service. Research and application of prescribed fire is increasing both in sheer numbers of acres, and in geographical range; historically, the use of prescribed fire was most common in the South (R-8). The use of heavy machinery is relatively evenly distributed among all Regions, except the Rocky Mountains (Regions 3 and 4), where it is emphasized to a much higher degree, and the South, where mechanical techniques for thinning are gaining in importance. Although manual methods are often thought to be impractical because of cost, they are frequently used in localized areas,

particularly the North (R-9).

Difficulties in evaluating alternative weed management practices are compounded by the strong interrelationships between weed management and the practice of silviculture. Management decisions involving harvesting, natural versus artificial regeneration, size of planting stock, species of crop tree, and others, all affect the need for, and the effectiveness of, weed management. Moreover, developments in forest utilization have the potential for increasing the value of "weed" species, thereby making once uneconomical methods practical.

5.0 WEED MANAGEMENT AND RESEARCH ON RANGELAND

As in forestry, the treatment of "weeds" in range management cannot easily be separated from the other tools of the profession. Vallentine (1971) described scientific range management on the premise that vegetation can be used perpetually for grazing. He further stated that range improvements need to be made a part of the planning and directing of range use rather than being considered separately. In order to clarify what can be accomplished by a range manager, he listed the factors on the range that could be manipulated, and what tools were available for improving the range (Appendix Table-11).

Weed management on rangeland has evolved from the basic grazing regulation and fire prohibitions of Sampson (1923), to range plant eradication as described by Stoddart and Smith (1955), and finally to integrated brush management systems, defined by Scifres (1979). As in the case of timber management, weed management for range improvement is seen as one major solution to the dilemma of increasing demand and reduced resources with which to meet it. Scifres (1978) described the "weed and brush problem" as being "of staggering magnitude, real and, in many cases, without effective solution." In a recent RPA Assessment, the USDA-Forest Service (1979a) provided data which support this conclusion (Appendix Table-12), by ranking rangeland conditions.

The USDA-Forest Service (1979a) concluded that only 46 percent of the rangelands in the 48 contiguous states is considered satisfactory. Further, certain major ecosystems are especially degraded. For example, only one out of six acres of annual grasslands is considered satisfactory. Moreover, unsatisfactory plains grasslands account for half of all the low condition grasslands.

This condition is even more critical when viewed in conjunction with projections for demand of range resources (USDA-Forest Service 1979a). Demand for improving range is anticipated to increase with public desire for red meat. However, the costs of range rehabilitation will influence the extent to which the demand for forage is met from rangelands.

When demand is projected on a regional basis, (Table 5-1; USDA-Forest Service 1979) the already stressed grassland and a shrubland are expected to be burdened with the largest increases in demand. Presently, including lands under all ownerships, fully half of the range grazing occurs in the Rocky Mountains and Great Plains (Forest Service Regions 1-4). Region 8 (the South) provides 29 percent of the Nation's grazing and the remaining 11 percent comes from the North (Region 9), and the Pacific Coast (Regions 5 and 6).

Table 5-1. Indices of range grazing in the contiguous states in 1976 by Region, with, projections of demand (medium level) to 2030 (1976 = 100). (Source: USDA-Forest Service 1979:235)

Region	Base		Projected demand			
	1976	1990	2000	2010	2020	2030
Northeast	100	125	138	150	163	175
Southeast	100	133	153	173	193	213
South Central	100	127	151	169	186	208
North Central	100	129	143	164	199	200
Rocky Mtns. & Great Plains	100	133	156	174	193	213
Pacific North- West	100	130	150	170	180	200
Pacific South- West	100	131	154	169	185	192
United States	100	131	153	171	188	208

In order to improve the availability of range resources, the USDA-Forest Service has turned (1979a) to weed management. In this section, trends in brush management and herbaceous range plant control will be examined. In addition, since the noxious farm weed program is administered through the Range Management Division of the USDA-Forest Service, it will be briefly discussed here.

5.1 Brush Management

Scifres (1978) identified woody plant management as the "historic major concern of many, if not most, range managers in the Southwest." Stoddart and Smith (1955) commented:

"There can be no question that some artificial brush control work is necessary on many range lands. Once established, vigorous woody plants such as mesquite, juniper, chamise, and sagebrush usually cannot be eliminated by good grazing practices alone, at least within economically feasible time."

Examination of the trends in accomplished brush management (Table 5-2) indicates that between 1969 and 1978 a general decline occurred, especially in Regions 1, 2, 3, 4, and 5. Regions 6 and 9 have been relatively stable, while brush management in Region 8 has increased dramatically. By far the most significant Region for range-related brush management is Region 4.

TABLE 5-2. Acres of accomplished brush management in the National Forest System by region (including Regions 1-9). Source: U.S.D.A. Forest Service, Washington Office range management files.

YEAR	REGIONS: 1	2	3	4	5	6	8	9	TOTAL
1978 ¹	2,960.7	6,149.5	12,100.0	21,438.0	4,111.7	5,466.0	27,707.0	781.0	68,613.9
1972 ²	4,140.4	6,898.1	15,022.9	35,575.3	12,193.3	6,667.6	3,391.0	898.6	69,764.3
1971 ²	2,639.7	6,063.9	37,743.3	37,943.0	5,790.3	4,854.6	3,892.8	760.2	61,944.5
1970 ²	5,779.7	11,542.9	37,441.8	42,688.8	8,840.9	5,274.4	11,393.7	1,194.1	86,714.5
1969 ²	11,056.2	14,774.8	50,965.0	36,111.1	6,235.7	17,724.5	8,746.8	1,177.8	95,826.9

¹Acres combined for cover manipulation/tallbrush and cover manipulation/short brush.

²Acres estimated by summing "range plant control" with "poison plant control" and applying corrections based on 1978 comparisons of "cover manipulation" and "range plant control." This process assumes that the relative emphasis of effort between brush control and forb control remained constant.

Several techniques for brush management are currently available alone, or in combination, to control unwanted brush on rangelands. These methods include prescribed fire, chemicals (applied using broadcast, selective, and/or soil techniques), mechanical treatments, seeding, biological control, hand methods, and combination techniques. Effects of other management practices on weed management will also be considered.

Prescribed Fire

The use of fire as a tool in brush management has undergone startling changes throughout the history of range management. Burning is the oldest known range improvement method, and has been used for centuries (Vallentine 1971). Although used in the early twentieth century, prescribed fire was severely criticized (Sampson 1923). By the mid 1950's, scientists such as Stoddart and Smith (1955) expounded the theory that fire played an important role in the succession of grass and shrub ecosystems, and human activities to suppress fire were one major cause for range deterioration. Present knowledge of the use of fire is augmented by recent developments in integrating fire with other control methods to manage chaparral (Green 1977) and mesquite (Scifres 1978, 1979). In addition, secondary benefits of fire prescribed for southern pine management are being recognized for range resources (Mobley et al. 1977). A detailed discussion of the extent of use of fire for weed control in forests is provided in sections 4.1 and 4.2.

The reasons for burning have been described by Vallentine (1971), and include (1) killing or suppressing undesirable brush plants, (2) preventing invasion of inferior species in the understory, and (3) increasing forage production and thus grazing capacity. Further, the author enumerated the advantages of burning as (1) except for erosion hazard, it is a technique widely applicable on all types of terrain, (2) it can be used on sites where mechanical equipment is not applicable, and (3) it can be accomplished quickly. The most important reason fire has not been favored is that, when not controlled properly, it can escape and sometimes cause disastrous damage.

Brush types which can be controlled by burning include sagebrush, pinyon-juniper (where a uniform burn can be obtained), and understory hardwoods in southern pine forests. Although it can offer temporary benefits in reducing chaparral and mesquite, the tendency of these brush types to resprout often renders the benefits of burning to be negligible after a short time (Vallentine 1971).

Martin and Bell (1978) summarized the current feelings toward fire as a brush management method for rangeland:

"Fire has been important in producing more palatable and nutritious forage for domestic livestock, whether in timbered or open range...Prescribed burning, possibly aided by chemical or mechanical treatment and seeding, can be used to rejuvenate desirable grasses. Once range is reconditioned and properly grazed, fire alone may be used to maintain a satisfactory condition" (at least in inland portions of Region 6, the area of discussion for this quote).

In its economic analysis, the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) estimated the cost of prescribed burning to control mesquite as \$0.50-\$3.00 per acre. The Team listed disadvantages to prescribed burning in the Southwest: (a) reclamation burning is a slow, tedious process; (b) present status of fire technology is far behind that concerning herbicide use; (c) the need for repeated burns is required for crown sprouters such as mesquite; and (d) prevailing attitudes concerning fire seriously restrict its application. Many of the advantages and disadvantages for fire are similar to those identified in the discussion of use in timber management.

Regional estimates of breakdowns of non-structural range improvement (cover manipulation) accomplishments by method reveal that the use of prescribed fire generally has increased relative to other methods in all Regions (Figure 5-1, Appendix Table-13). Fire is the most important range management tool in Regions 8 and 1 where almost all non-structural range management is done with fire. Regions 3 and 4 are burning more acres than Region 1, but fire accounts for only a third of the acres treated (Table 5-3) in each. Moreover, range benefits are documented as a secondary objective for timber management funded "prescribed burning to control understory vegetation" (Table 4-9).

Examination of USDA-Forest Service research accomplishments (Appendix Table-14) reveals that a great deal of emphasis is placed on developing prescribed fire technology for range use in comparison to total research in the field of range weed management, and this emphasis is increasing (Figure 5-2). Comparing work accomplished between Experiment Stations (Table 5-4), the Rocky Mountain and Intermountain Stations have greater levels of emphasis than others. However, significant emphasis on this topic also occurs at the Southern and Pacific Southwest Experiment Stations.

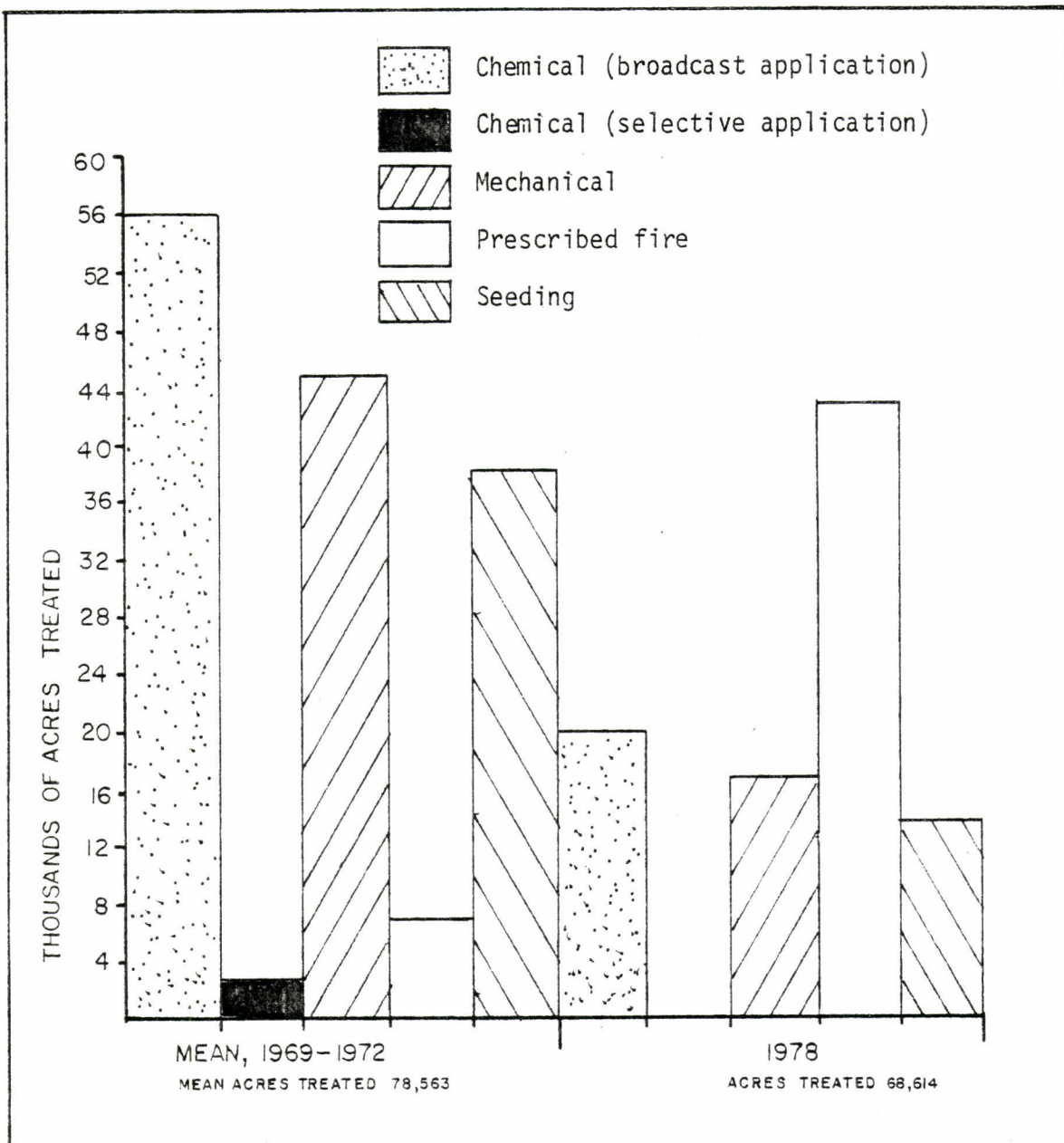


FIGURE.5-1. Methods of range brush management accomplishments¹ (Source: USDA-Forest Service regional estimates).

¹Only the major methods, which in sum account for 95 percent or more of the area treated, are reported here. Data for 1973, 1974, 1975, 1976, and 1977 are not available.

TABLE 5-3. Regional USDA-Forest Service use of various methods of range brush management, in acres, for 1978 (Source: USDA-Forest Service Regional Estimates).

Region	METHOD					
	Fire	Chemical ¹	Mechanical	Seeding	Hand	Biological
1	2,810.7	-	-	150.0	-	-
2	371.0	4,853.0	925.0	-	0.5	-
3	3,900.0	-	8,200.0	5,950.0	-	-
4	6,958.0	6,966.0	7,514.0	7,514.0	-	-
5	1,000.0	3,111.7	-	-	-	-
6	279.0	5,122.0	65.0	164.0	-	-
8	27,707.0	-	-	-	-	-
9	-	-	153.0	-	628.0	-
TOTAL	43,025.7	20,052.7	16,857.0	13,778.0	628.5	-
¹ Broadcast application						

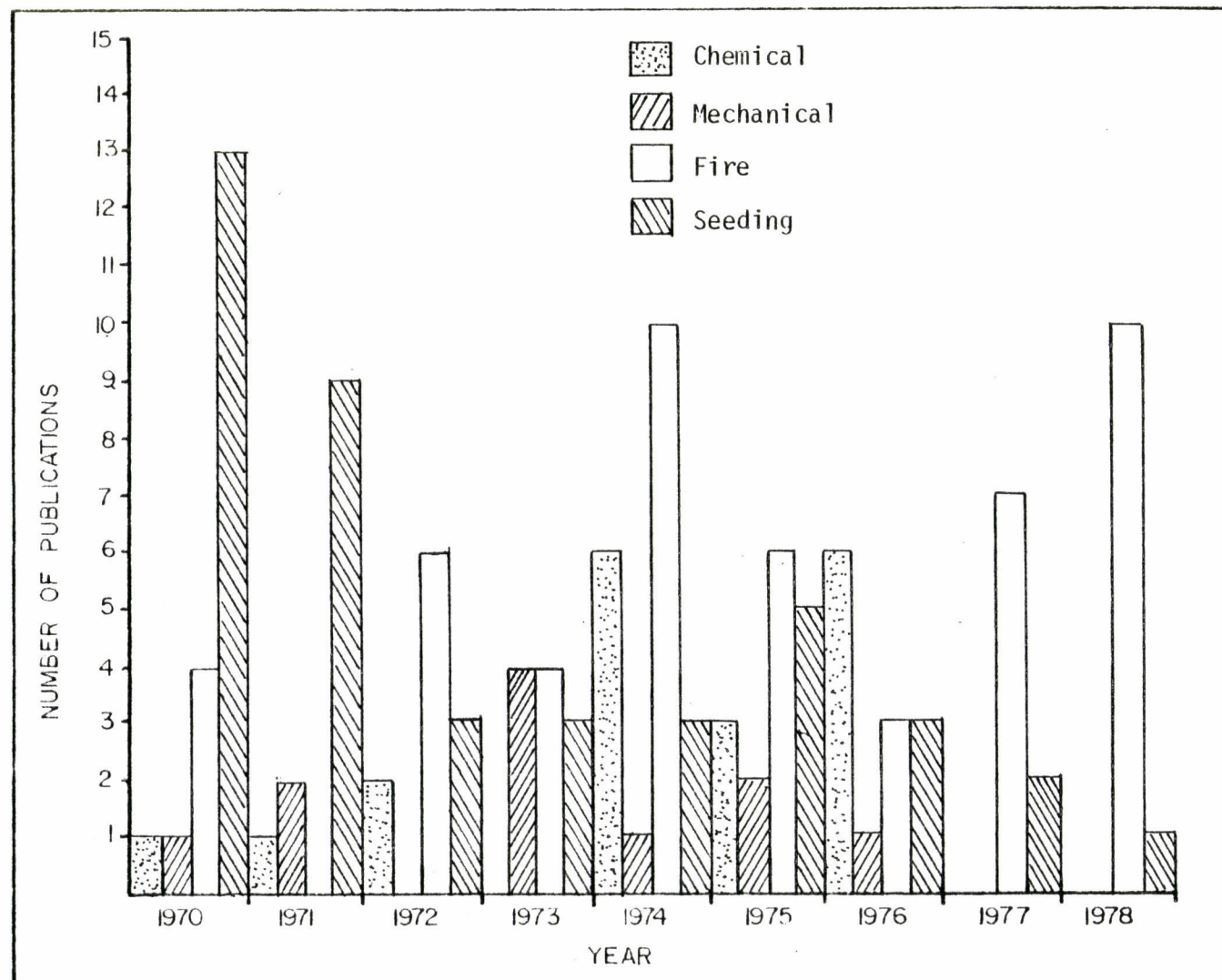


FIGURE 5-2. Annual comparisons of number of research reports in Forest Service annual research accomplishments (1970-1978) which address various methods¹ of range brush management.

¹Only the major methods, which account for 95 percent or more of the research publications that consider a specific method, are reported here.

TABLE 5-4. Number of research reports listed in Forest Service annual research accomplishments (1970-1978) which address various methods of range brush management, with comparisons among Experiment Stations.

EXP. STN.	METHOD				Total
	Chemical	Mechanical	Fire	Seeding	
INT	1	2	12	6	21
NE	1	-		1	2
NC	-	-	2	-	2
PNW	2	-	3	3	8
PSW	-	-	6	1	7
RM	11	5	15	17	48
SE	-	2	4	2	8
SO	3	1	7	2	13
FPL	-	-	-	-	-
WO	-	-	-	-	-
OTHER	1	1	1	10	13
TOTAL	19	11	50	42	122

Chemical Brush Management

Significant numbers of range managers feel that herbicides are critical to effective brush management (Scifres 1978, Vallentine 1971). The U. S. Department of Agriculture and the U. S. Department of the Interior (1966), Johnsen (1967), Pond (1967), Hedrick (1967), and Young *et al.* (1967) provided recommendations on the specific herbicides to be used for each important species of range weed. The most often recommended herbicides for brush have been the phenoxy herbicides, including 2,4,5-T, 2,4-D, and Silvex (Appendix Table-15). Vallentine (1971) included these herbicides in a compilation of herbicides for range (Appendix Table-16).

Regional estimates of the use of broadcast herbicides (Appendix Table-17) and selectively applied chemicals (Appendix Table-18) show that the use of herbicides comprised a significant portion of cover manipulation accomplishments. Comparing these data over time (Figure 5-1) reveals that the use of herbicides for weed management on rangelands has declined between the early 1970's and the present. Declines in chemical brush management are especially evident in Regions 1 and 3 where overall range brush management has also declined considerably. The decline in acres treated with herbicides in 1978 occur concurrently with changes in Forest Service policy which effectively restrict application of 2,4,5-T and Silvex on National Forest Lands. The most significant uses of herbicides occur in Regions 6, 2, 4, and 5 (Table 5-3). Witt (1978) noted that in 1976, range rehabilitation only accounted for 5.5 percent of the USDA-Forest Service's herbicide use (Table 4-7).

Methods of application include broadcast over large areas and individual treatment of each "weed" shrub or tree. Herbicides can be broadcast by either aerial or ground equipment. Trees or shrubs can be treated individually by spraying foliage, stems, or cut stumps. In addition, herbicides can be injected into trunks of individual trees, or poured into frills made by hand tools. With the use of pelletized herbicides, applications can be made directly to the soil, and absorbed through the roots of target individuals.

In its economic analysis, the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) assumed direct application costs of aerial spraying of herbicides on mesquite to range \$4.35-\$12.00 per acre, and spot treatments to range \$6.00-\$10.00 per acre. Vallentine (1971) also listed advantages and disadvantages of chemical treatment. In his opinion, advantages included: (1) cheaper than most mechanical control methods, but may cost more than fire; (2) can be used where mechanical methods are impossible, such as on steep or rocky slopes; (3) reduces labor requirements for treatment; (4) provides a selective means of killing certain weed and

brush species such as root sprouters that cannot be efficiently controlled by other methods; (5) grasses usually escape damage when directions for use are followed; (6) maintains a grass and litter cover and does not expose soil to erosion; (7) provides a rapid control method from the standpoint of both plant response and acreage covered; and (8) safer than fire when proper safeguards are used.

The disadvantages considered by Vallentine (1971) are: (1) no chemical control has yet proven effective for some species, (2) herbicides provide a desirable seedbed for grass seeding only under certain conditions, (3) costs of control may outweigh expected benefits on low value range, (4) the careless use of chemicals is hazardous to cultivated crops and may contaminate water supplies, and (5) herbicides may kill associated forbs and shrubs important for wildlife. Further, Vallentine (1971) noted that the use of herbicides has received much public attention, which has resulted in a considerable degree of opposition to the use of chemicals.

Categorization of USDA-Forest Service research into the subject of broadcast herbicides for range purposes (Appendix Table-19) reveals that very little research effort has been expended on this subject in the years 1970-1978. Most of the research took place at the Rocky Mountain Experiment Station (Table 5-4) during the period 1974-1976 (Figure 5-2).

During the period 1970-1978 only four publications dealt with selective herbicide application techniques on rangeland. All of these, likewise, originated at the Rocky Mountain Experiment Station. Other agencies in USDA, such as the SEA, are actively engaged in research involving chemical treatment of range weeds.

Mechanical Brush Management

Stoddart and Smith (1955) noted "The high cost of mechanical operations and the soil disturbance involved discourage the method except on the highly productive lands." The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) estimated costs of mechanical treatment to range from \$6.00-\$22.50 per acre. Further, the Team described available methods for mechanical treatment as shredding, roller chopping, power grubbing, chaining, dozing, and root plowing. These methods differ widely in their applicability to range improvement. Vallentine (1971) described the uses of various mechanical treatments (Appendix Table-20). Common problems include: inadequate control of sprouting species, inability to operate in heavy cover, high costs and high energy use.

Breakdown of Regional cover manipulation accomplishments (Appendix Table-21) reveals that the use of mechanical treatment for weed management has been significant, but declining (Figure 5-1). The areas where these methods predominate (as a fraction of total accomplishment) include Regions 3 and 9. Significant acreage is also treated in Regions 4 and 2 (Table 5-3).

Research by the USDA-Forest Service on mechanical methods of range weed management (Appendix Table-22) was less intensive (during the period 1970-1978) than on either prescribed fire or broadcast herbicides (Figure 5-2). As in the case of other range weed management techniques, the subject of mechanical range brush management is stressed to the greatest extent at the Rocky Mountain Experiment Station (Table 5-4).

Seeding

Although seeding serves to increase competitive ability of favorable range plant species, it also is used to meet management objectives other than plant control, such as reducing erosion, providing vegetation cover after other means of plant control have been accomplished, and providing nutritious forage (Vallentine 1971).

Stoddart and Smith (1955) and Vallentine (1971) noted that perhaps range seeding has been overemphasized. Seeding of desirable range vegetation is perhaps most commonly employed in combination with other brush management techniques. In general, seeding is accomplished more effectively by drilling than by broadcast seeding, and some form of land preparation is recommended prior to drilling (Stoddart and Smith 1955). Green (1977) included seeding as one step in the type conversion process for chaparral.

Estimates of range seeding as an element of regional Forest Service accomplishments (Appendix Table-23) indicate that the use of seeding has dropped from being used in approximately 40,000 acres manipulation projects during the period 1969-1972 to 13,500 acres in 1978 (Figure 5-1). This decline in emphasis is also suggested by the Forest Service accomplishment reporting system. Prior to 1973, the system distinguished between seeding and other aspects of non-structural range improvement. At present, such data are not separated. The most pronounced use of seeding occurs in Regions 3 and 4 (Table 5-3).

As an activity for research, (Appendix Table-24) range seeding has been a point of emphasis in USDA-Forest Service programs, (Table 5-4) second only to prescribed fire. However, a sharp decline in emphasis occurred between 1969-1972, and 1978 (Figure 5-2). As is the case with other range improvement techniques, research has been spearheaded by the Rocky Mountain Experiment Station (Table 5-4).

Biological Control of Range Brush

One avenue for biological brush control, goat grazing, was evident in early range management, and it has been mentioned sporadically ever since (Sampson 1923; Scifres 1978). However, most recent discussions on the use of goats to control brush observe that limitations do exist to this method. Green (1977), for example, described goat grazing as useful for maintaining long-term ground cover "when other treatments provide the major brush removal." Henry (1979, personal communication) noted that goat grazing has been used to a limited extent for brush removal in California, but is only feasible where a market exists for goat products. Scifres (1978) identified necessary expenditures for goat grazing as additional shelter, fencing, predator control, and others. Vallentine (1979) described goats as probably the most effective grazers for control of undesirable woody range plants.

Vallentine (1979) noted other grazing techniques which have been demonstrated as biological control. These include using mature cattle in winter to control small soapweed (Yucca glauca) in Nebraska, using sheep and deer to reduce tall larkspur, (a plant poisonous to cattle) using heavy early spring grazing to stimulate bitterbrush (a valuable browse species for big game), controlling sagebrush by heavy late fall grazing of sheep, grazing sheep to control scattered stands of Klamath weed in California, and recognizing the benefits to cattle range by browsing deer.

Other biological control mechanisms, however, are not developed to as great an extent. In fact, Stoddart and Smith (1955) cautioned against too rapid development of biological techniques. This is qualified by noting that several successful applications of biological techniques, using insects, are known, including prickly pear control in Australia, Lantana in Hawaii, gorse in New Zealand, and Saint Johnswort in America. Vallentine (1971) described these and other examples of biological control, including control of tansy ragwort, and the potential of using the mesquite twig girdler (Oncideres rhodosticta) to control undesirable brush in Texas.

No use of biological control as cover manipulation was reported by Forest Service regional personnel. Although the use of biological control by the Forest Service is minimal, biological control that is used, especially that accomplished by grazing, is not reported as non-structural range improvement.

Stewart (1979) noted that a great deal of information remains to be gathered before increased use of biological control can be obtained. Categorization of USDA-Forest Service research accomplishments reveals that between 1970 and 1978, only five publications addressing biological weed control on rangelands have been sponsored. These studies came through the Intermountain Experiment Station, and dealt with the topic of goat grazing.

Hand Control of Brush

Manual control has not been considered a viable alternative for range brush management for quite some time (Scifres 1978; USDA-States-EPA 2,4,5-T RPAR Assessment Team 1979; Stoddart and Smith 1955). Hand methods have not always been so costly, or held in such low regard by professional range managers (Sampson 1923). Of course, at that time, other methods were not available.

Vallentine (1971) described the current uses of manual methods as: (1) clearing scattered plants just invading grasslands; (2) cleaning up following other control methods; (3) maintaining cleared areas against reinvasions; and (4) removing limited stands of poisonous plants or new infestations of the more troublesome plants before they have an opportunity to spread further. The author described these methods as slow, and normally adapted to small areas. He listed methods of manual control as grubbing, cutting, and girdling.

The USDA-Forest Service has not used manual methods recently to any significant degree. In most years, and for most Regions, there has been no use or little (less than 5%) use of manual methods. Exceptions are Region 8 in 1969, where manual control was used in 6.6 percent (573.2 acres) of the cover manipulation accomplished, and Region 9 in 1978, where 80.4 percent of the cover manipulation (628.0 acres) was accomplished manually (Table 5-3).

Combination Techniques

As can be seen from the previous discussion, no one method for range brush management has proved to be universally applicable, or even the one successful method on any given site. Therefore, recent attention is turning to the use of several methods in combination to accomplish control. This concept has been termed integrated brush management (Scifres 1979).

Scifres described how this concept could be utilized for mesquite control, a major range problem in the Southwest (USDA-Forest Service Region 3, portions of Region 4 and Region 8 in Texas), as well as McCartney rose, and whitebrush. Further use of combination techniques has been described (Green 1977) for the chaparral

systems of California (USDA-Forest Service Region 5).

For this study, each Forest Service Region was asked to list the 3 to 5 most common combination treatments used for non-structural range improvement. From the results, it did not appear that complex combinations, such as integrated brush management systems, were used. However, difficulties with interpreting these results should be noted. All data were expressed on an annual accomplishment basis, so programs encompassing several years would not be visible. By definition, integrated brush management systems span 5 to 15 years (Scifres 1978).

The most common combinations reported involved seeding with some other method (usually mechanical or fire, but also chemical in Region 6). Region 9 reported using the combinations mechanical/hand and selectively applied chemicals/hand. Region 6 reported the only combinations of three methods, including mechanical/prescribed fire/seeding and selective chemical/hand/seeding.

Although considerable development of combination techniques has occurred, USDA-Forest Service research accomplishments have not emphasized interest in this area. Eight publications have been published between 1970 and 1978 which address this subject. Interested units include the Rocky Mountain Experiment Station, and the Intermountain Experiment Station.

Effects of Other Range Management Practices on Brush Management

Range scientists and managers agree that the prime influence on quality of vegetation is the grazing pressure placed on the range (Scifres 1978, Stoddart and Smith 1955). Vallentine (1971) agreed that grazing was the number one factor contributing to the increase, spread, and invasion of weeds. As other factors, the author listed reduction of fire, seed transport by grazing animals, seed dissemination by small animals, climatic fluctuations, cultivation and subsequent abandonment, local denudation, and increase in commerce.

Grazing in all the National Forest System is regulated by the USDA-Forest Service. Research on developing improved grazing systems is a long-term objective of the USDA-Forest Service. Recently (1970-1978) research trends have been stable in this area, and concentrated in the Rocky Mountain, and Intermountain, Experiment Stations (Table 5-5). The extent of implementation of improved grazing systems is difficult to determine. Often, the systems have been met with resistance from permittees.

TABLE 5-5. Number of Forest Service research reports¹ which address the topic of improving grazing systems.

YEAR	EXPERIMENT STATIONS:			PNW	PSW	RM	SE	SO	FPL	WO	OTHER	TOTAL
	INT	NE	NC									
1978 ²	-	-	-	1	-	2	-	-	-	-	-	3
1977 ²	-	-	-	1	-	1	1	1	-	-	-	4
1976	2	-	-	2	-	4	-	-	-	-	-	8
1975	1	-	-	-	2	3	-	-	-	-	-	6
1974	-	-	-	-	-	-	-	1	-	-	-	1
1973	3	-	-	-	3	2	-	-	-	-	-	8
1972 ³	2	-	1	-	-	3	-	1	-	-	-	7
1971 ³	1	-	-	-	-	1	-	-	-	-	-	2
1970 ³	-	-	-	-	-	-	-	-	-	-	9	9
TOTAL	9	0	1	4	5	16	1	3	-	-	9	48

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize the article with the title only.

³Not all articles were abstracted in these annual reports.

A second potential effect is that of increased utilization of waste brush. This is noted by Green (1977) and discussed previously in this text, within the context of timber management.

Summary

In the USDA-Forest Service, the amount of range brush management accomplished declined after 1970. This trend is especially evident in Regions 1, 2, 3, 4, and 5. Historically, brush management has been most extensively practiced in Region 4, and to a lesser extent in Region 3. However, treatments to reduce unwanted brush have dramatically increased in Region 8.

The use of prescribed fire as a tool for brush management increased approximately 500 percent from the mean of 1969-1972 to 1978. Increased fire use is largely the result of the active range program in Region 8 where fire has long been an accepted tool and general acceptance of fire in the west (Regions 1, 3, and 4). This has only partially offset a trend away from other brush management tools, including chemical and mechanical methods as well as seeding.

While it is evident that grazing is considered by the Forest Service as a technique for manipulation of range vegetation, its role as a biological weed control device is not evident from the Forest Service reporting system. Other biological devices are in their infancy, and have found limited use in the Forest Service. Manual methods for brush management are used only slightly on National Forest Lands. The use of combination treatments, such as sophisticated Integrated Brush Management Systems, cannot be determined using an annual reporting system, such as that used by the Forest Service.

The bulk of the research on all brush management techniques for rangeland have occurred at the Rocky Mountain and Intermountain Experiment Station. Research on prescribed fire has generally been more evident than research on other methods. Moreover, the number of publications on prescribed fire have been increasing, while research publications for other methods have declined.

5.2 Herbaceous Range Plant Control

The USDA-Forest Service also seeks to control a variety of grasses and forbs which are characterized as pests. Some of these species are not desirable simply because they are not used by livestock or wildlife, while other species are unwanted because they can poison valuable livestock if consumed in sufficient quantity.

Annual accomplishments in range plant control (Table 5-6) indicate a general decline between 1969-1972, and 1978. By far the most significant area for this type of work is Region 4. Range plant control comprises a distinctly less important role than brush

TABLE 5-6. Acres of accomplished range plant control in the National Forest System, by region (including Regions 1-9) (Source: USDA Forest Service, Washington Office range management files).

YEAR	REGIONS 1	2	3	4	5	6	8	9	TOTAL
1978 ¹	2,042.0	1,001.0	625.0	3,077.0	410.4	600.4	1,000.0	881.0	9,636.8
1972 ²	2,853.6	1,122.9	774.1	5,128.7	1,220.7	659.4	123.0	1,013.9	12,896.3
1971 ²	1,819.3	987.1	1,944.7	5,470.0	579.7	533.4	141.2	857.3	12,332.7
1970 ²	3,983.3	1,879.0	1,929.2	6,154.2	881.8	579.5	413.2	1,349.6	17,169.3
1969 ²	7,619.8	2,405.2	2,626.0	5,205.9	624.3	1,947.5	317.2	1,328.2	22,074.1

¹Data transcribed from Forest Service files.

²Acres estimated by summing "range plant control" with poison plant control, and applying corrections based on 1978 comparisons of "cover manipulation" and "range plant control." The process assumes that the relative emphasis of effort between brush control and forb control remained constant.

management. In 1978, for example, brush management accounted for 68,314 acres (Table 5-2) while range plant control was accomplished only on 9,012 acres. Therefore, range plant control made up only 12 percent of the accomplishments which could be strictly defined as range weed management. Many range managers feel that undesirable poisonous plants, at least, can be tolerated to a certain extent (Stoddart and Smith 1955).

Methods for herbaceous range plant control include those described in the previous discussion on brush management. Although minor differences exist between the brush and herbaceous species management (such as herbicides used, types of mechanical treatment, etc.), the scope of effort in this program does not warrant an additional detailed discussion of alternative methods.

Examination of Forest Service estimates of accomplishments by method (Table 5-7) indicates that herbicides applied using broadcast methods was by far the most often used technique, and especially prevalent in Regions 1, 2, 4, and 6. The next most widely used was mechanical, which was favored in Region 3, 5, and 9. Prescribed fire seemed to be the most favored method in Region 8.

5.3 Noxious Farm Weeds Management

In recognizing its responsibility to landowners adjacent to National Forests, the USDA-Forest Service assists in controlling weeds whose seeds originate on National Forests, and can contaminate nearby agricultural lands. This program is funded through the Forest Insect and Disease Management Division, while it is administered by the Range Management Division.

Annual accomplishments reveal that a considerable increase in the program occurred between 1969 and 1978 (Table 5-8). This increase can be partially explained by Congressional mandates for this program. The greatest amount of treatment has been accomplished in Region 1, followed by Regions 6, 4, 2, 9, 5 and 8.

From accomplishment data broken down by method in the Regions (Table 5-9), it is obvious that chemical means have served as the prime method used to control noxious farm weeds. However, since noxious farm weeds account for only a small part of the total weed management in the Forest Service, it does not account for a large part of Forest Service herbicide use. Witt (1978) calculated that noxious weeds made up only 1.6 percent of Forest Service herbicide use in 1976 (Table 4-7). Noxious farms weeds were controlled biologically to some extent in Regions 1, 5, and 6.

TABLE 5-7. Mean percent¹ (for the years 1969-1972, 1978) of range plant control accomplishments by method for all Forest Service Regions.

METHOD	REGION:								OVERALL
	1	2	3	4	5	6	8	9	
Prescribed fire	8.6	0	0	4.4	0	1.0	74.6	0	6.1
Mechanical	10.7	25.7	56.2	30.8	49.4	8.2	1.1	97.9	33.4
Chemical (Broadcast)	80.8	73.9	13.5	67.4	34.9	87.1	38.8	0	60.0
Chemical (Selective)	0	0.4	12.8	2.3	15.7	3.8	0.6	0.2	2.9
Biological	0	0	0	0	0	0	0	0	0
Hand	0	0	0	0	<0.1	1.7	1.3	1.9	0.3
Seeding	1.2	13.9	33.5	30.8	53.2	31.3	17.7	51.0	25.4

¹Data gathered by requests to Forest Service regional offices. Data given here was calculated using the following formula:

$$\text{Mean percent} = \Sigma \frac{(\text{accomplishment by method } i / \text{total accomplishment}) \times 100}{5 \text{ years}}$$

Totals for each region do not equal 100% due to the use of combination treatments and rounding errors.

TABLE 5-8. Acres accomplished by the U. S. Forest Service under the noxious farm weeds program.¹

	REGIONS 1	2	3	4	5	6	8	9	TOTAL
1978	3,746.0	2,227.7	-	4,045.2	74.0	7,667.7	175.0	607.0	18,542.6
1972	1,054.4	834.0	-	2,175.0	170.0	438.0	70.0	917.0	5,658.4
1971	3,071.1	536.0	-	917.0	178.0	800.0	-	619.0	6,121.1
1970	2,825.6	415.0	-	847.0	78.0	586.0	-	670.0	5,421.6
1969	1,558.1	705.0	-	732.5	21.0	1,480.0	-	850.0	5,346.6

¹Data compiled from U. S. Forest Service, Washington office range management files.

TABLE 5-9. Mean percent¹ (for the years 1969-1972, 1978) of noxious farm weeds control accomplishments by method for Forest Service regions.

METHOD	REGION:								OVERALL
	1	2	3 ²	4	5	6	8	9	
Prescribed fire	0	0	-	0	0	0	0	0	0
Mechanical	2.7	0	-	0	0	0.1	0	0.8	0.6
Chemical (Broadcast)	94.7	0	-	0	0	0.1	0	0	13.0
Chemical (Selective)	0	100.0	-	99.3	91.0	81.6	100.0	93.6	76.7
Biological	2.1	0	-	0	2.4	18.0	0	0	8.2
Hand	0.5	0	-	0.7	6.7	0.3	0	5.6	1.4
Seeding	0	0	-	0	0	0.1	0	0	0.1
TOTAL	100.0	100.0	-	100.0	100.1	100.2	100.0	100.0	100.0

¹Data gathered by requests to Forest Service regional offices. Data given here was calculated using the following formula:

$$\text{Mean percent} = \frac{\sum (\text{annual accomplishment by method} / \text{annual total accomplishment}) \times 100}{5 \text{ years}}$$

²No noxious farm weed control has been accomplished for the period reported.

The USDA-Forest Service accomplished little research in the area of noxious farm weeds. This topic of research is delegated to other agencies in the U. S. Department of Agriculture, and to private industry.

SUMMARY

In range management, the methods which can be used to control unproductive woody vegetation or destroy herbaceous species which are either of low forage value or poisonous to livestock are the same--fire, chemical, and mechanical. By far the most important form of weed management is controlling woody vegetation.

The oldest method of brush control on the range is prescribed fire. Although it was once considered by some to be destructive, the theory of fire as a prime moving force in grassland ecology has become accepted by the range management profession. Both use of prescribed fire and research on this method have notably increased in the USDA-Forest Service.

Herbicides have long been thought of as being potentially very effective but only recently have they been developed into a useable methodology. However, when compared to timber management, herbicide use for range management in the USDA-Forest Service is relatively small. In the Forest Service, this use is declining.

Mechanical methods have proven their worth, but are limited by economics to productive sites. Emphasis on mechanical methods are declining in the Forest Service. Hand methods are generally thought to be uneconomical for large areas.

Particularly troublesome species which are not easily controlled, such as mesquite, have served as the impetus for developing combinations of herbicide, fire, and mechanical means. These techniques have been most extensively used in Texas, the Southwest, and California, but there are no means for documenting their use in the Forest Service.

Research on the various methods of range weed management has been concentrated at the Rocky Mountain and Intermountain Experiment Stations. In recent years, research emphasis has shifted toward prescribed fire, and away from chemical, mechanical and seeding techniques.

In the case of range management, as in timber management, significant interrelationships exist between weed management and the natural resource sciences as a whole. Most significant are decisions related to grazing intensity, timing of grazing, and choice of species to graze. All these factors influence the ability of desirable vegetation to compete with "weeds," and the establishment of poisonous plants.

6.0 WEED MANAGEMENT AND RESEARCH ON RIGHTS-OF-WAY AND FUELBREAKS

6.1 Rights of Way

Management objectives for rights-of-way differ markedly from those of forests and rangelands. Whereas forest and range managers seek to maximize the useable benefits which can be derived, right-of-way managers seek primarily to protect these areas from damage by vegetation, or to reduce hazards to man caused by unwanted vegetation. For purposes of this discussion, rights-of-way include electric transmission lines, pipelines, highways, and railroads. The extent of rights-of-way is quantified (Appendix Table-25) on a regional basis by the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979). The "Eastern" Region corresponds approximately to Forest Service Regions 8 and 9, while the "Central Plains and Rocky Mountains" Region is encompassed by Forest Service Regions 1, 2, 3, and 4, and the "West Coast Region," along with Hawaii, comprise Forest Service Regions 5 and 6. Alaska is considered by the Forest Service to comprise Region 10.

Fifty-five percent of all right-of-way acreage occurs in the Eastern Region, much of which is located in the heavily populated areas of the Northeast. The Central Plains and Rocky Mountain Region contains 36 percent of the right-of-way acreage, while 9 percent is located in the West Coast Region. The remaining 1 percent occurs in Alaska and Hawaii.

Regional differences in the extent of weed management of rights-of-way not only occur because the amount of rights-of-way differ, but also because of regional differences in the vegetation. Where forest is predominate, such as in the Eastern Region and parts of the West Coast Region, woody vegetation is likely to be more of a problem than in areas, such as the Central Plains and Rocky Mountain Region, where grasslands predominate (USDA-States-EPA 2,4,5-T RPAR Assessment Team 1979).

Several methods of accomplishing weed management on rights-of-way exist, including chemical, mechanical, manual, (Asplundh Environmental Services 1978), and in selected cases, prescribed fire (Arner et al. 1976). The following text discusses each method, and examines the extent of use of all methods.

Weed management of Forest Service rights-of-way is usually accomplished by the agency or organization responsible for the right-of-way, instead of the Forest Service (Fuera 1979, Van Doren 1979, personal communication). Accomplishment data on the National Forest System are very limited, and cannot be analyzed by methods. Further, there is no evidence from analysis of Forest Service annual research accomplishments that indicates active involvement

by the Forest Service in research specifically on rights-of-way. However, data are available that permit the analysis of the relative use of various methods over all rights-of-way, and will be presented herein. Moreover, specific methods outlined by Forest Service policy will be noted.

Chemical Right-of-Way Weed Management

Forty-seven percent of all firms managing rights-of-way use herbicides when treating these areas (Table 6-1; Asplundh Environmental Services 1978). The highest relative amount of herbicide use occurs in the Northeast (Region 9), where 56 percent of all firms use some herbicides for right-of-way weed management, and 42 percent chemically treat more than 70 percent of their right-of-way acreage. In the Southeast (Region 8), chemical treatment is somewhat less important, since it is used by 51 percent of all firms. Finally, the West (Forest Service Regions 1-6) where 40 percent of all firms use herbicides, places the least emphasis on the use of herbicides.

Several types of herbicides are available for use on rights-of-way and a variety of methods to apply these herbicides also exists. Asplundh Environmental Services (1978) identified these as broadcast foliar, selective foliar, selective basal, granular, tree injection, and cut stump.

Although differences in efficacy between herbicides do exist, perhaps a larger debate, and greater research effort, occurs on the topic of optimum application method. Historically, much of the herbicide application on rights-of-way has been accomplished using broadcast foliar methods (aerial spray and ground broadcast). However, a good deal of effort has demonstrated that selective methods, (cut stump, selective basal, and, to a lesser extent, selective foliar) can be used to create a stable shrub or grass cover. This cover type becomes relatively maintenance free in the long-term, and provides significant multiple-use benefits by providing for vegetation diversity, creating near-optimal wildlife habitat, increasing opportunities for outdoor recreation, and improving aesthetics (e.g., Bramble *et al.* 1957, 1958; Cavanagh *et al.* 1976; Egler 1952, 1958; Egler and Foote 1975; Fowler *et al.* 1976; Niering 1958; and Niering and Goodwin 1974).

Estimates of treatment costs are provided by Niering (1978). Costs for broadcast foliar sprays are listed as \$100-\$124 per acre, while basal spraying ranges from \$74 to \$221, and averages about \$130. Cut stump treatment methods vary in cost from \$139 to \$723 per acre, and average \$347 (using Tordon 155) and \$464 (using 2,4,5-T). In addition, long-term costs are generally lowered with selective treatments, since development of "stable shrub" communities lessens the need for periodic treatments, as the existence

TABLE 6-1. Comparison of vegetation management methods for rights-of-way (Source: Asplundh Environmental Service, 1978).

	REGION				INDUSTRY				
	TOTAL	NORTH-EAST	SOUTH-EAST	WEST	LARGE ELECTRIC UTILITIES	SMALL ELECTRIC UTILITIES	RAIL-ROADS	PIPE-LINES	HIGHWAYS
<u>MANUAL</u>									
Firms using manual treatments	76%	77%	75%	73%	78%	81%	76%	41%	81%
Firms who manually treat >70% of ROW	38	28	31	48	28	51	--	16	--
Firms who manually treat <10% of ROW	29	37	37	19	38	16	63	48	80
<u>MECHANICAL</u>									
Firms using mechanical methods	60	65	82	49	63	50	72	71	100
Firms who mechanically treat >70% of ROW	39	35	52	35	31	41	11	56	51
Firms who mechanically treat <10% of ROW	16	23	9	11	24	18	6	9	3
<u>CHEMICAL</u>									
Firms using chemical treatments	47	56	51	40	64	35	92	26	81
Firms who chemically treat >70% of ROW	28	42	7	16	45	18	35	12	--
Firms who chemically treat <10% of ROW	30	20	44	40	22	35	17	59	40

of dense stands of shrubs precludes invasion by undesirable tall-growing tree species (Niering 1978, Bramble et al. 1958).

Niering (1979) listed the advantages of selective herbicide treatment as: (a) preservation of desirable plant cover and development of a relatively stable mosaic of vegetation types that deters future tree invasion, (b) excellent root kill of undesirable species, (c) creation of excellent wildlife cover, and (d) high esthetic values. Disadvantages include; (a) somewhat higher initial cost, (b) difficulties in steep terrain or otherwise inaccessible areas, and (c) availability of manpower.

Some advantages of broadcast treatment are: (a) lower initial cost, and (b) no limitations of terrain or accessibility. Niering (1979) listed several disadvantages, which include; (a) lack of selectivity, (b) loss of desirable ground cover, (c) inadequate root kill of undesirable species, (d) drift of chemicals and damage to desirable growth including home gardens, agricultural crops and watersheds, and (e) opening of site conditions for the potential invasion of undesirable tree growth.

From a sample of companies which engage in right-of-way weed management, the relative amount of effort on each chemical application technique is quantified (Table 6-2; Asplundh Environmental Services 1978). While broadcast methods are most common in the Southeast, stump spraying, selective basal, and selective foliar are used more commonly in the Northeast. There is about an equal use of all application methods except that granular broadcast treatments are used much less than the others.

In Region 9, the USDA-Forest Service (1966) stated policies which favor the use of selectively applied herbicides over broadcast methods. For this, the Forest Service receives considerable praise by the scientific community (Niering 1978).

Witt (1978) calculated that 11.6 percent of 1976 Forest Service herbicide use occurred for right-of-way management purposes.

Mechanical Right-of-Way Management

Asplundh Environmental Services (1978) described mechanical methods as the use of machines to cut the stems of the target vegetation in a broadcast, nonselective manner. Available methods include rotary mowing, shear dozing, and roller chopping. Rotary mowing serves to cut woody and herbaceous vegetation above the ground line. The method of shear dozing involves use of a tracked vehicle equipped with a sharp blade, that shears all stems, up to 10 inches d.b.h., above ground level. Roller chopping involves mounting cutting blades on water-filled metal drums, and pulling these over the area with heavy machinery. Plants, up to 6 inches

TABLE 6-2. Useage patterns of chemical methods on rights-of-way (Source: Asplundh Environmental Services, 1978).

	REGION				INDUSTRY				
	TOTAL	NORTH-EAST	SOUTH-EAST	WEST	LARGE ELECTRIC UTILITIES	SMALL ELECTRIC UTILITIES	RAIL-ROADS	PIPE-LINES	HIGHWAYS
<u>BROADCAST FOLIAR-AIR</u>									
Percent who use	26%	26%	40%	20%	34%	22%	21%	36%	--
Use on >70% of ROW	11	9	25	9	14	13	13	18	--
Use on <10% of ROW	6	6	7	6	7	4	4	12	--
<u>BROADCAST FOLIAR-GROUND</u>									
Percent who use	28	28	36	19	28	18	44	--	72%
Use on >70% of ROW	13	13	13	13	6	10	31	--	48
Use on <10% of ROW	2	3	5	1	5	2	--	--	4
<u>SELECTIVE FOLIAR</u>									
Percent who use	24	27	11	21	27	14	18	24	56
Use on >70% of ROW	9	12	4	9	10	9	4	12	16
Use on <10% of ROW	5	5	2	4	7	--	--	--	24
<u>SELECTIVE BASAL</u>									
Percent who use	29	31	21	24	41	28	5	6	20
Use on >70% of ROW	9	13	6	9	14	12	4	--	--
Use on <10% of ROW	6	5	8	3	8	7	--	--	4
<u>STUMP SPRAYING AFTER CUTTING</u>									
Percent who use	25	29	19	23	29	23	9	6	40
Use on >70% of ROW	8	10	4	8	11	11	--	--	8
Use on <10% of ROW	10	12	9	9	12	5	9	6	20
<u>GRANULAR BROADCAST</u>									
Percent who use	12	12	8	14	11	12	22	6	12
Use on >70% of ROW	3	2	3	6	4	6	--	--	--
Use on <10% of ROW	4	6	2	3	5	2	13	--	8
<u>GRANULAR SPOT</u>									
Percent who use	23	23	24	23	26	19	44	6	20
Use on >70% of ROW	6	4	6	9	4	12	9	--	--
Use on <10% of ROW	12	15	13	11	18	3	26	6	20
BASE	(278)	(151)	(64)	(99)	(110)	(103)	(23)	(17)	(25)

in diameter, are cut into small pieces.

All mechanical methods are highly energy intensive, unselective, and limited by terrain. In many instances, they do not serve to control root sprouting. They do avoid the controversy of herbicide use, and where appropriate slopes occur, are economical. Average costs, as estimated by the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979), are \$183 per acre.

Mechanical treatments are used by 60 percent of all firms that manage rights-of-way (Table 6-1). Therefore, mechanical treatment is utilized more commonly than all forms of chemical treatment, and is the most common treatment with firms that rely on one method for 70 percent or more of their right-of-way management. It is heavily favored in the Southeast, (82 percent) but also very popular in the Northeast, where 65 percent of all firms utilize this method. Mechanical treatment is used by all highway departments, and is used in over 70 percent of the highway maintenance accomplished by most departments.

Manual Right-of-Way Maintenance

Asplundh Environmental Services (1978) identified manual methods as the utilization of handheld tools to cut individual target species. Tools include chainsaws, axes, brushaxes, and scythes. Methods include complete cutting as well as girdling. The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) estimated that manual control costs average \$657 per acre.

Asplundh Environmental Services (1978) noted that severe limitations exist for the use of manual methods for right-of-way management. These include: (a) lack of available manpower, (b) hazardous nature of the work, (c) ineffective results, and (d) high cost. Niering (1978) stated that manual methods have historically been the major method used, having been available prior to the advent of herbicides.

Even today, manual methods are used by 76 percent of all firms that manage rights-of-way (Table 6-1). Although no great differences exist between Regions on the percentage of firms that use this technique, firms that use it in over 70 percent of their right-of-way maintenance tend to be more concentrated in the West than elsewhere. Although a considerable number of railroad and highway departments use manual techniques, it is used only by 51 percent of the small electric utilities, and 16 percent of the pipeline companies as the method of choice (applied to greater than 70 percent of all right-of-way maintenance).

Prescribed Fire as Right-of-Way Maintenance

Although the use of prescribed fire is not considered to be an alternative for right-of-way management by Asplundh Environmental Services (1978) and the USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979), Niering (1978) saw possibilities for this technique in certain circumstances.

Arner et al. (1976) described the use of fire, combined with fertilization, as a technique for managing rights-of-way. In selected instances, the procedure was augmented by seeding food plants for quail, turkey, and cottontail rabbit. By applying these techniques, it was found that winter burns, scheduled every third year, could be successfully applied to a wide variety of right-of-way situations where broadcast herbicides had been used extensively in the past, and that these burns could effectively control unwanted woody vegetation. Moreover, the authors concluded that significant benefits could accrue to wildlife by using this method, instead of broadcasting herbicides.

Niering (1978) noted that air pollution could create a problem, if this technique were utilized. The USDA-States-EPA 2,4,5-T RPAR Assessment Team (1979) and Asplundh Environmental Services (1978) did not describe use of fire on right-of-ways, and no data are available which permit quantification of the actual use of prescribed fire for right-of-way management. It is estimated, however, that this use is very small.

Summary

Management of vegetation on rights-of-way seeks to reduce hazards to humans and equipment associated with vegetation on or adjacent to these structures. Major methods involve the use of chemicals either through broadcast or selective application, mechanical equipment, or manual labor. The need for such activity is dependent upon the extent of right-of-way acreage, which is far more pronounced in the Northeast than in any other section of the country, and on the type of vegetation of the area, which is more problematic in the Eastern and Pacific Coast sections than it is in the Central Plains and Rocky Mountains.

The use of selective vegetation management methods (usually involving selectively applied herbicides) receives a great deal of research attention in the Northeast, where Forest Service regional policy stipulates its use. However, the Forest Service is not actively engaged in right-of-way vegetation management research. Since the Forest Service does not compile right-of-way weed management accomplishments, it is difficult to determine how much reliance is placed on one method versus the others. Data for industry as a whole indicate that a relatively even distribution of all weed management methods occurs.

6.2 Fuelbreaks

Green (1977) described weed management on fuelbreaks as "the permanent conversion of vegetation on strategically located areas for fire control which occupy a relatively small part of the total wildland acreage." This program has been developed and implemented in the past 20 years, and evolved from principles surrounding the construction and use of firebreaks, which were used extensively in the 1930's. Henry (1979, personal communication) reported that by far the most extensive use of fuelbreaks occurs in California (Forest Service Region 5). Fuelbreaks are often planned in systems, since that is thought to be more effective than isolated segments. One prime use is protection of urban areas or valuable natural resources, so locations are planned accordingly. Ridgetops are thought to be particularly successful locations, but fuelbreaks can also be placed successfully at the base of mountains, in wide canyon bottoms, or elsewhere. Minimum widths range from 200 to 300 feet, but wider breaks are preferred wherever possible, since the wider the break, "the easier and safer the job of holding fire on it."

Four major steps are evident in the construction and maintenance of fuelbreaks. These include: (1) removal of brush, including preparation of a seedbed if introduced species are to be sown, (2) establishment of a ground cover, including sowing or planting of introduced species, (3) control of brush regrowth to eliminate excess competition from woody plants, and (4) maintenance of the stable new cover.

In all these steps, several optional methods are available to accomplish brush removal. Hand methods and mechanical methods can be used singly or in combination with prescribed burning to kill unwanted brush and dispose of it. Prescribed burning can also be used alone, or in combination with herbicides, to prepare vegetation by dessicating it prior to using fire. The phenoxy herbicides, including 2,4-D, and 2,4,5-T, are recommended for this purpose. Each of these options has distinct procedures and tradeoffs, which are similar to those discussed in relation to timber and range management.

Options for establishing ground cover include natural regeneration and seeding. In order to ensure prompt revegetation artificial seeding is recommended. Several choices as species to seed are also available. Major groups from which to select include annual herbaceous plants and perennial grasses. Within these groups, several species are available from which to choose. Proper choice is based on site characteristics.

Several alternatives are also available for controlling brush regrowth and eliminating excess competition from woody plants. Although the options are similar to those previously discussed; mechanical, hand, fire, and chemical, choices are somewhat constrained by the need to control woody brush while not destroying desirable vegetation. Perhaps the most effective techniques involve the use of herbicides, applied either by broadcast or selection methods, or the application of prescribed fire.

These same methods: mechanical, hand, fire, and chemical, can be used to maintain the stable new cover. In addition, good wildlife and livestock management is recommended, in order that woody brush may be controlled by browsing. Goat grazing may prove especially valuable in this regard. If, however, thin stands of brush cannot be adequately controlled by browsing, selective methods of applying herbicides, or hand grubbing, are recommended.

Green (1977) estimated that in 1972, some 1,850 miles of fuel-breaks existed in California, distributed widely throughout the state. Witt (1978) reported that fuelbreak management served as the objective for approximately 1.6 percent of Forest Service herbicide use in 1976. Forest Service research is concentrated in one USDA-Forest Service research work unit, which has operated under the auspices of the Pacific Southwest Experiment Station for over 20 years.

SUMMARY

On rights-of-way, management objectives differ from those of timber or rangelands in that no commodity is produced for market. Instead, weed management is aimed at insuring the uninterrupted flow of goods and services. Perhaps the most significant need for right-of-way weed management, is in the Northeast. Herbicides, heavy machinery, and manual methods are all used operationally. Prescribed fire combined with seeding and fertilization has been tested in the South, but has not yet become an operational technique.

Many research findings compare economic and environmental effects of the use of selectively applied herbicides to those of chemical broadcast and mechanical techniques for right-of-way management. This research indicates that selectively applied herbicides offer multiple-use benefits and reduced costs over other alternatives. In Region 9, USDA-Forest Service policy is to apply these selective techniques wherever possible, but actual accomplishment data to document the use of various methods are unavailable. However, private industry does not seem to show nearly as great a preference for selectively-applied herbicides.

Fuelbreaks, which are designed to halt the spread of wildfires, are used most extensively in California. These areas are created by using combinations of herbicides, prescribed fire, mechanical methods, and hand labor. These same methods are used to maintain areas, along with provisions to make optimum use of biological control in the form of wildlife and livestock grazing. Conceptually, at least, the fuelbreak program calls for sophisticated integration of all methods to accomplish weed management. Although some 1,850 miles of fuelbreaks exist, the use of herbicides for this activity constitutes a very small proportion of total Forest Service herbicide use.

7.0 DEVELOPMENTS IN ENVIRONMENTAL ANALYSIS OF WEED MANAGEMENT ACTIVITIES

While it is beyond the scope of this report to render a detailed literature review of the environmental effects of weed management activities, it should be recognized that the USDA-Forest Service is obligated, through NEPA, in house guidelines (FSM 1950), and others, to consider the effects of its weed management activities on the environment. This chapter will briefly discuss the activities of Forest Service research to identify and quantify environmental effects, and will touch on the current controversy regarding the effects of herbicides. The activities of the Forest Service regarding actual compliance to NEPA are discussed in Section 2.12.

7.1 Research

Although the Forest Service has long been charged with maintaining environmental quality, its responsibilities in this area have taken on new dimensions in recent years. One milestone may be the passage of NEPA. After that, the preparation of environmental statements became mandatory. Also mandated were provisions to require public participation in the environmental assessment process.

In order to advance knowledge in impact evaluation, the Forest Service (Timber Management Research, Forest Environment Research, and Forest Fire and Atmospheric Sciences Research), and universities continue to research the environmental effects of various weed management alternatives (Stewart 1979, Table 7-1). Heavy emphasis is placed on determining the environmental effects of prescribed fire on air quality, as well as the effects of prescribed fire and mechanical treatments on water quality. Additionally, a significant amount of effort is expended in order to quantify resource values, so they may be applied in an overall modelling scheme. Effects of weed management on plant succession, soils, and safety are also being studied. Moreover, the fate and persistence of herbicides is being examined, as are mechanisms of transport of herbicides through ecosystems.

The basic research used to document environmental relationships is seen as one vehicle to open new avenues of technology development, so that improved methods of weed management may be discovered. For example, with respect to timber management, research is underway in the Forest Service to determine the effects of harvesting systems on soils, watershed values, and regeneration. Since harvesting can affect the success of regeneration and the vegetation community which invades after cutting, it is a factor in weed management. This is also the case when comparisons of

TABLE 7-1. USDA Forest Service^{a/} and federally^{b/} funded university research on the environmental effects of weed management (FY 1978) (Source: Stewart 1979).

	NORTH Uni- ver- sity		SOUTH Uni- ver- sity		ROCKY MOUNTAINS Uni- ver- sity		PACIFIC COAST Uni- ver- sity			TOTAL UNITED STATES Uni- ver- sity			
	FS	SCIENTIST YEARS:	FS		FS		FS		EDC ^{c/}	FS		EDC	Total
Herbicide fate	0	0	0.6	0	0	0	2.0	0	0	2.6	0	0	2.6
Resource values	5.3	0.7	3.5	2.3	8.7	0	0.5	0.3	0	18.0	3.3	0	21.3
Water and air	3.0	0.3	12.4	0	4.5	0	1.9	0.2	0	21.8	0.5	0	22.3
Plant succession	1.0	1.1	1.3	0.8	6.3	0	1.5	0.5	0	10.1	2.4	0	12.5
Soils	1.3	0.9	3.0	0	0	0	1.4	0	0	5.7	0.9	0	6.6
Safety	0	0	0	0	0	0	0	0	1.1	0	0	1.1	1.1
TOTAL	10.6	3.0	20.8	3.1	19.5	0	7.3	1.0	1.1	58.2	7.1	1.1	66.4

a/ USDA, Forest Service (Forest and Range Experiment Stations (FS) and Equipment Development Centers)

b/ State, Hatch, and McIntire-Stennis funding as reported in the Current Research Information System (CRIS)

c/ USDA, Forest Service, Missoula, MT and San Dimas, CA Equipment Development Centers.

natural vs. artificial regeneration methods are made, since the density and vigor of the crop trees may differ and affect the need for weed management. Development of genetically improved stock can also lead to changes in the need for weed management since increased growth could allow the planted trees to overtop competing vegetation. Comparisons between various size planting stock, and containerized seedlings vs. bare root stock also seek to determine vigor of the crop tree, and thus enabling evaluation of the competitive ability of the desired species, and the need for weed management. Research into new utilization methods can change the very definition of "weed" in individual management programs. Finally, basic research into the fields of life history and ecology, for both crop trees and weeds, can lead to improved understanding of how much, and what kinds of control are necessary, appropriate, and efficient.

In range management, it was pointed out earlier that the chosen level of grazing intensity, and choice of grazing pattern are the prime working forces in altering range vegetation. The Forest Service is researching the effects of grazing systems on vegetation. Studies which seek to optimize the mix of desirable plants to be seeded can also influence the need for weed management, since one factor in the proper choice of introduced species is the ability to compete with "weed" species. Finally, studies on the basic ecology of range vegetation can lead to further evaluation of the need to control unwanted plants, and identify limiting factors which could be used for control purposes.

7.2 The Controversies Surrounding the Use of Herbicides.

The use of herbicides for any forestry purpose is subject to much scrutiny from the public and from other governmental agencies. This is illustrated by the recent EPA ban on the use of 2,4,5-T for forestry purposes, due to possible teratogenic effects on humans. Although a considerable effort has been expended studying these possible effects, there is much discussion on whether or not such impacts do occur.

The popular press, such as Whiteside (1979) and various television documentaries present discussions supporting the view that herbicides (especially 2,4,5-T) do have harmful effects. Their conclusions are supported to some extent by toxicological research (USDA-States-EPA 2,4,5-T RPAR Assessment Team 1979). Other studies concluded that possible toxicological side effects from herbicides are not as significant as imagined (Cranmer 1978; McLeod and Committee 1971). Each viewpoint is criticized by the other not only on the basis of conclusions, but also on the basis of methodologies.

TABLE 7-2. Number of Forest Service research reports¹ which address the subject of environmental effects caused by herbicides.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	OTHER	TOTAL
1978 ²	-	-	-	7	-	-	-	-	-	-	1	8
1977 ²	-	-	-	3	1	2	-	2	-	-	-	8
1976	-	-	-	3	-	1	-	1	-	-	-	5
1975	-	1	-	8	-	-	-	-	-	-	-	9
1974	-	-	-	3	-	1	-	-	-	-	-	4
1973	-	-	-	3	-	-	-	-	-	-	-	3
1972 ³	-	-	-	10	-	-	-	-	-	-	-	10
1971 ³	-	1	-	6	-	-	-	-	-	-	-	7
1970 ³	-	-	-	1	-	-	1	-	-	-	8	10
TOTAL	0	2	0	44	1	4	1	3	0	0	9	64

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles without abstracts.

Some research has been undertaken in the USDA-Forest Service on the effects of herbicides. This has concentrated on measuring ecosystem transport, persistence, and effect on wildlife habitat (Table 7-2). Norris at the Pacific Northwest Experiment Station has researched toxicological effects of herbicides on fish.

Not only are the toxicological effects of herbicides the subject of much controversy, but so is the level of responsibility needed by the Forest Service in examining these effects. While it is generally agreed that the Forest Service is not responsible for developing basic toxicological data, there is some precedent to indicate that the Forest Service is responsible for presenting, evaluating, and interpreting the best available information on herbicide uses addressed in environmental statements (Citizens Against Toxic Sprays, Inc. vs. Bergland, 428 F Supp. 908, 927 (D. Ct. Or. 1977)). Feeling still exists in the Forest Service that this area is more appropriately the authority of EPA, especially since the Forest Service is not adequately staffed with toxicological expertise to accomplish this task.

8.0 WEED MANAGEMENT ISSUES

ISSUE NUMBER 1: Integrated pest management has become official Forest Service policy. How can field personnel form an adequate understanding of the concept and share a common working definition?

IPM directives have been issued from Washington to the field, where there is considerable confusion as to how IPM differs from existing pest management practices. Accordingly, many people in the field have indicated that there is an overall lack of direction from the Washington office.

ISSUE NUMBER 2: Do Forest Service pest management projects include: (1) thorough examination of available control alternatives, (2) comprehensive analysis of impacts, and (3) evaluations to assess project results?

Forest Service activities are frequently controlled by cost/benefit analyses and environmental assessments prior to the conduct of the project. Few post-project evaluations are made in either the economic or environmental monitoring areas. Post-treatment evaluations should be incorporated, both as a means of documenting what actually happened during and after the project, and as a way to improve the information on which future projects are planned.

Program activities frequently do not cite administration and overhead costs in consideration of economic effectiveness. These costs, as well as similar costs, should be clearly stated to more accurately reflect the true costs of a project.

ISSUE NUMBER 3: The Forest Service is presently developing and implementing alternative pest control methods, such as: prevention, biological, and cultural techniques. Can the present rate of progress in research and implementation adequately meet the need for development and cope with the problems which arise?

Considerable basic research effort and a good deal of money is needed to develop the ecological expertise necessary for effective biological and cultural control mechanisms. Since it is basic research, probabilities are small that specific results applicable to weed management will become available soon. Nevertheless, institutional constraints which limit the use of conventional techniques also make the need for development alternatives more severe.

Cultural methods, such as planting with more competitive or tolerant species, have economic ramifications in that price differences between alternative species are real. Such techniques, when practiced today, are rarely documented as "weed management."

Hand control, once the only method available, has long been considered uneconomical by professional resource managers. However, some sectors of the public remember it as an effective technique. Since little hard data are available to resolve the controversy, the practicality of hand control for weed management remains an issue.

Opportunities for developing usable products from "weed" vegetation offer possibilities to make once uneconomical techniques practical. However, the extent to which these techniques will be applied to vegetation will not only depend upon their economics, but also upon the abilities of research and management to coordinate activities between the disciplines of resource management and resource utilization.

ISSUE NUMBER 4: Can project decisions be traced to agency goals and objectives?

The Resources Planning Act and the National Forest Management Act require the Forest Service to prepare periodic inventories and assessments of the resources, i.e., timber, range, wildlife, recreation, minerals, and water, on the National Forest System lands. Potential resource outputs are projected and compared to historical supply/demand data to indicate the need for these products. Projections can then be used to determine resource output, or products, that the National Forest should provide, and to establish target levels of outputs for the resources.

Output goals are set for all lands in the National Forest System. The goals are hierarchically structured with National, Regional, Forest, and District targets. The decision of a District Ranger to undertake (or not undertake) a particular project must be put in the perspective of the District's annual targets. Can individual projects be shown to contribute to the overall targets of the Forest, Region, and the National Forest System?

ISSUE NUMBER 5: Is the Forest Service public involvement effort, with regard to pest management, providing the public with adequate information and is the agency responsive to public concerns?

In order to resolve conflicts, the Forest Service must be able to not only present its concerns eloquently, but also demonstrate that it understands, and is responsive to public concerns. On the one hand, the Forest Service faces a large task in distilling all

the applicable knowledge developed by research and all the experience from management into a form which the public, without prior background in forestry or range management, can comprehend. By the same token, the public expects the Forest Service to lend an attentive ear to their concerns, and are quick to point out instances in which this did not seem to occur. Faced with individuals firmly entrenched in diametrically opposed positions, the Forest Service is expected to carry out a solution which is in harmony with all desires.

ISSUE NUMBER 6: Is the USDA-Forest Service efficiently organized to handle weed management problems?

There is no single staff organizational structure in the USDA-Forest Service to direct, review, and coordinate weed management. This has resulted in broad differences among the methods used by resource managers throughout the National Forest System.

The Forest Insect and Disease Management staff has been responsible for overseeing and reviewing the use of herbicides, largely because of the unit's expertise with other pesticides. FI&DM responsibility will be formally extended to review all pest management including weeds, as a result of the authorities delegated to the Deputy Chief for S&PF by the IPM Manual revision. This raises the question of the character of FI&DM's role in weed management.

ISSUE NUMBER 7: Are pest management communications and cooperation between the Forest Service and other areas of Government and the private sector adequate?

In order to fulfill its pest management role, the Forest Service has to interact with other government agencies and departments and with private industry and individuals. These interactions involve a wide array of subjects, including: (1) technology transfer with other agencies that have similar missions; (2) input into developing regulatory processes; and (3) provision of services to other agencies or groups to aid them in managing pest problems.

In some instances, especially those involving the latter two types of interaction, conflicts can develop between the Forest Service and the other agency(ies) or private groups merely because of different missions and perspectives. These conflicts can be either productive, or self-defeating. If the USDA-Forest Service is able to balance the presentation of its own needs with the flexibility necessary to accomplish the goals of interagency relations it can be an effective factor in any one decision, and can encourage future interactions between these same areas of government.

ISSUE NUMBER 8: Do adequate mechanisms exist to provide detailed exchange between Forest Service researchers, university researchers, and forest managers?

Communication among these groups could serve a multitude of purposes, including (a) insuring that research in the Forest Service is not duplicated by university or private research; (b) making managers aware of the latest state-of-the-art developments; (c) informing researchers of management's need for improved information and techniques; and (d) developing presentation methods for research results which are understandable at the management level. A long-standing complaint of many managers is that research does not provide the guidance they need, within a reasonable time frame, to conduct adequate day-to-day resource management activities. On the other hand, researchers often note that studies proposed by managers have already been completed. Many available reports may gather dust on library bookshelves due to disfavor or lack of visibility.

ISSUE NUMBER 9: Do Forest Service data systems provide decision makers with adequate information?

Line officers at all levels of the Forest Service need adequate information not only to base their decisions on strong scientific evidence, but also to document their reasoning for any pest management decision. If this information does exist or can be collected, but is not properly utilized, the Forest Service may be subjected to severe criticism from other Federal agencies and the public. In order to be usable, data must be comprehensive and presented in an understandable manner. Data collection must be sensitive enough to provide the needed information and data management methods and presentation must be sophisticated enough to provide the line officer with comprehensive, yet manageable knowledge.

Data management problems can occur at all levels of the Forest Service. In the Washington office, for example, there may or may not be a need to examine how present policies affect Regional, Forest, and District line officers' choices between various alternatives of insect, disease, or weed control alternatives. CNA found, however, that the use of various methods could not be compared at the national level. The only control method quantified is pesticide use, through FI&DM. This information has not proved comparable to the general data collected by other staff groups.

9.0 LITERATURE CITED

- American Paper Institute and National Forest Products Association
1978. Benefits of 2,4,5-T in forest management. American Paper
Institute/National Forest Products Association. Washington, D.C.
139 p.
- Arner, D.H., L.E. Clibrun, D.R. Thomas, and J.D. Manner. 1976.
The use of fire, fertilizer, and seed for rights-of-way
maintenance in the southeastern United States, pp. 156-165 In:
Tillman, R. (Ed.). Proceedings of the first national symposium
on environmental concerns in rights-of-way management. Mississippi
State University. Mississippi State, Mississippi. 335 p.
- Asplundh Environmental Services. 1978. Benefit analysis; use
of 2,4,5-T for vegetation management on rights-of-way. Asplundh
Environmental Services. Willow Grove, Pa. 44 p.
- Balmer, W.E., H.L. Williston, G.E. Dissmeyer, and C. Pierce. 1976.
Site preparation-why and how. Forest Management Bulletin. USDA-
Forest Service, S.E. Area State and Private Forestry. Atlanta,
Georgia. 8 p.
- Bernstein, A. 1978. Using a chainsaw to control brush. J. Forestry
76(8):474-475.
- Bernstein, A. 1979. Resprouting of manually cut brush. Josephine
County Forestry Department. Grants Pass, Oregon. 7 p. + tables.
- Bernstein, A. and L. Brown. 1977. Seven immediate consequences
resulting from the use of a chainsaw to control brush. Josephine
County Forestry Department. Grants Pass, Oregon. 24 p.
- Black, H.C. and B.T. Vladimiroff. 1963. Effect of grazing on
regeneration on Douglas-fir in southwest Oregon. Proc. Society of
American Foresters Annual Mtg. Div. of Range Mgmt. p. 69-76.
- Bramble, W.C., W.R. Byrnes, and R.J. Hutnik. 1958. Effects of
chemical brush control upon game food and cover. Pennsylvania
St. U. Ag. Exp. Sta. Prog. Rept. 188. 7 pp., 6 photos, 1 graph.
- Bramble, W.C., W.R. Byrnes, and D.P. Worley. 1957. Effects
of certain common brush control techniques and materials on
game food and cover on a power line right-of-way. Penn. St.
Univ. Agr. Exp. Sta. Prog. Rept. 175. 4 pp., 6 photos.

- Carter, M.C. 1979. Vegetation management: an integral part of forestry. pp. 20-24. In: Gale, R.D. (Ed.). Proceedings for Integrated Pest Management Colloquium. USDA-Forest Service Gen. Tech. Rept. 14. Washington, D.C. 76 p.
- Carter, M.C., H.A. Holt, and W. Rickard. 1978. Alternative methods of vegetation management for timber production. pp. 125-137. In: D.E. Ketchum (coordinator). Symposium on the Use of Herbicides in Forestry. U.S. Dept. of Agric., Office of the Secretary. Washington, D.C. 213 p.
- Cavanagh, J.B., D.P. Olson, and S. Macriganis. 1976. Wildlife use and management of powerline rights-of-way in New Hampshire pp. 275-285 In: Tillman, R. (Ed.). Proceedings of the first national symposium on environmental concerns in rights-of-way management. Mississippi State University, Mississippi State, Mississippi. 335 p.
- Clark, F.B. 1979. Personal communication. USDA-Forest Service, Timber Management Research. Washington, D.C.
- Council on Environmental Quality. 1979. The President's Environmental Program. Washington, D. C.
- Cranmer, M. 1978. Toxicology of families of chemicals used as herbicides in forestry. pp. 53-69, In: D.E. Ketchum (coordinator). Symposium on the Use of Herbicides in Forestry. U.S. Dept. of Agric., Office of the Secretary. Washington, D.C. 213 p.
- Crouch, G.L. and E. Hafenstein. 1977. Atrazine promotes ponderosa pine regeneration. USDA-Forest Service Research Note PNW-309. USDA-Forest Service. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. 8 p.
- Dierauff, T.A. 1978. Use of herbicide on non-industrial private forest land. pp. 119-123, In: D.E. Ketchum (coordinator). Symposium on the Use of Herbicides in Forestry. U.S. Dept. of Agric., Office of the Secretary. Washington, D.C. 213 p.
- Dimock, Edward J. II; Enoch Bell, and Robert M. Randall 1976. Converting brush and hardwoods to conifers on high sites in western Washington and Oregon-Progress, policy, success and costs. USDA-Forest Service Res. Pap. PNW-213, 16 p. illus. Pac. Northwest Forest and Range Experiment Station, Portland, Oregon.
- Egler, F.E. 1958. Science, industry and the abuse of rights-of-way. Science 127(3298):573-580.

- Egler, F.E. 1952. Transmission lines as wildlife habitat. The Land 11 (2): 149-152.
- Egler, F.E. and S.R. Foote. 1975. The plight of the ROW domain victim of vandalism Part I. Futura Media Serv., Mt. Kisco, N.Y. 294 p.
- Fowler, D.K., L.C. Marcum, R.R. Pugh, and D.C. Francisco. 1976. Cooperative wildlife habitat development along transmission line corridors. pp. 296-301. In: Tillman, R. (Ed.). Proceedings of the first national symposium on environmental concerns in rights-of-way management. Mississippi State University. Mississippi State, Mississippi. 335 p.
- Fueren, W. 1979. Personal communication with David Cottingham. USDA-Forest Service, Washington, D.C.
- Fullerton, R. 1979. Personal communication.
- Gillespie, R. 1979. Personal communication. U.S. Forest Service: Timber Management, Washington, D.C.
- Gjerstad, D.H., L.R. Nelson, and D.B. South. n.d. The Auburn University forestry chemicals cooperative. Alabama Forests
- Gratkowski, H. in press. Growth of Douglas-fir after release from snowbrush ceanothus. Draft manuscript submitted to Forest Science for publication.
- Gratkowski, H. 1978. Herbicides for shrub and weed tree control in Western Oregon. USDA-Forest Service Gen. Tech. Rept. PNW-77. USDA-Forest Service, Pacific Northwest Forest and Range Experiment Stn. Portland, Oregon. 48 p.
- Gratkowski, H. 1976. Herbicides for grass and forb control in Douglas-fir plantations. USDA-Forest Service Research Note PNW-285. USDA-Forest Service, Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 7 p.
- Gratkowski, H. 1975. Silvicultural use of herbicides in Pacific Northwest forests. USDA-Forest Service Gen. Tech. Rept. PNW-37. USDA-Forest Service, Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 44 p.
- Gratkowski, H. 1974. Herbicidal drift control: aerial spray equipment, formulations, and supervision. USDA-Forest Service Gen. Tech. Rept. PNW-14. USDA-Forest Service, Pacific Northwest Forest and Range Exp. Station. Portland, Oregon. 12 p.

- Green, L.R. 1977. Fuelbreaks and other fuel modification for wildland fire control. U.S. Dept. Agric., Agric. Handb. 499. Washington, D.C. 70 p., illus.
- Groundwork Inc. 1978. Willamette Brush Control Study Project-revised preliminary report. Eugene, Oregon.
- Hedrick, D.W. 1967. Conversion of sagebrush ranges to productive grasslands. pp. 200-213, In: Symposium Proceedings: Herbicides and vegetation management in forests, ranges, and noncrop lands. Oregon State Univ., Corvallis. 356 p.
- Horowitz, H. 1979. Personal communication. Groundwork, Incorporated. Eugene, Oregon.
- Jackson, R.S. 1977. Use of prescribed fire in site preparation. pp. 1-3, In: Proceedings site preparation Workshop West. USDA-Forest Service. Atlanta, Ga. 40 p.
- Jackson, R.S. 1974. Fire as a tool in young pine management. pp. 65-76, In: Proceedings symposium on management of young pines. USDA-Forest Service. Atlanta, Georgia. 349 p.
- Johnsen, T.N., Jr. 1967. Herbicidal control of noncommercial conifers on rangeland. pp. 220-226, In: Symposium Proceedings: Herbicides and vegetation management in forests, ranges, and non-crop lands. Oregon State Univ., Corvallis. 356 p.
- Jones, E.P., Jr. 1974. Precommercial thinning for slash and loblolly pines. pp. 229-233, In: Proceedings symposium on management of young pines. USDA-Forest Service. Atlanta, Ga. 349 p.
- Kaufman, H. 1960. The forest ranger. Johns Hopkins Press, Baltimore. 241 p.
- Lawrence, W.H., and J.D. Walstad. 1978. The ecological basis for vegetation management. pp. 113-117, In: D.E. Ketchum (coordinator). Symposium on the Use of Herbicides in Forestry. U.S. Dept. of Agric., Office of the Secretary. Washington, D.C. 213 p.
- Lewis, C.E. 1974. Grazing considerations in managing young pines. pp. 106-170, In: Proceedings Symposium on Management of young pines. USDA-Forest Service. Atlanta, Ga. 349 p.
- Lyon, L.J., H.S. Crawford, E. Czuhai, R.L. Fredrikson, R.F. Harlow, L.J. Metz, and H.A. Pearson. 1978. Effects of fire on fauna; a state-of-knowledge review. USDA-Forest Service Gen. Tech. Rept. WO-6. Washington, D.C. 41 p.

- Martin, R.E. and J.D. Bell. 1978. Planning for prescribed burning in the inland Northwest. USDA-Forest Service, Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 67 p.
- Micheal, J. 1979. Personal communication. USDA-Forest Service. Auburn, Alabama.
- Miller, R.S. and Committee. 1975. Pest control: an assessment of present and alternative technologies. Vol. IV. Forest pest control. National Academy of Sciences. Washington, D.C. 170 p.
- Mobley, H.E. 1974. Fire as a tool in young pine management. pp. 234-242, In: Proceedings Symposium on management of young pines. USDA-Forest Service. Atlanta, Ga. 349 p.
- Mobley, H.E., R.S. Jackson, W.E. Balmer, W.E. Ruziska, and W.A. Hough. 1977. A guide for prescribed fire in southern forests. USDA-Forest Service, Southeastern Area. Atlanta, Georgia. 40 p.
- MacLeod, C.M. and Committee. 1971. Report on 2,4,5-T, a report of the panel on herbicides of the President's Science Advisory Committee. Executive Office of the President, Office of Science and Technology. Washington, D.C. 68 p.
- McLemore, B.F. 1977. Control of hardwoods with chemicals. pp. 11-15, In: Proceedings site preparation workshop west. USDA-Forest Service. Atlanta, Ga. 40 p.
- Nelson, T.C. 1978. Vegetation management on public lands: an overview with special reference to herbicides. pp. 105-113; In: D.E. Ketchum (coordinator). Symposium on the use of herbicides in forestry. USDA-Forest Service, Office of the Secretary, Washington, D.C. 213 p.
- Newton, M. 1979. Personal communication. Oregon State University, Corvallis.
- Newton, M. 1978. Vegetation management alternatives in the practice of silviculture. Proc. Soc. Amer. Foresters Ann. Mtg., Albuquerque. pp. 270-277.
- Newton, M. 1973. Environmental management for seedling establishment. Oregon State University Forest Research Laboratory. Research Paper 16.

- Niering, W.A. 1979. Right-of-way vegetation management: alternative control techniques. pp. 17-19 In: R.D. Gale (ED.). Proceedings for Integrated Pest Management Colloquim. USDA-Forest Service Gen. Tech. Rept. WO-14. Washington, D.C. 76 p.
- Niering, W.A. 1978. Right-of-way vegetation management: an evaluation of techniques and alternatives. pp. 171-181, In: D.E. Ketchum (coordinator). Symposium on the use of Herbicides in Forestry. U.S. Dept. of Agric., Office of the Secretary. Washington, D.C. 213 p.
- Niering, W.A. 1958. Principles of sound right-of-way vegetation management. Economic Bot. 12: 140-144.
- Niering, W.A. and R.H. Goodwin. 1974. Creation of relatively shrublands with herbicides: arresting "succession" on rights-of-way and pastureland. Ecology 55:784-795.
- Pearson, H.A. 1975. Range and wildlife opportunities. pp. 19-27. In: Proceedings symposium on management of young pines. USDA-Forest Service. Atlanta, Georgia. 349 p.
- Pond, F.W. 1967. Conversion on chaparral and scrub hardwood to productive range. pp. 214-219, In: Symposium Proceedings: Herbicides and vegetation management in forests, ranges, and noncrop lands. Oregon State Univ., Corvallis. 356 p.
- Puuri, C. 1979. Personal communication. U.S. Forest Service: Timber Management. Washington, D.C.
- Reese, D.C. 1979. Evolution of pest management. pp. 10-12. In: R.D. Gale (Ed.). Proceedings for Integrated Pest Management Colloquim. USDA-Forest Service Gen. Tech. Rept. WO-14. Washington, D.C. 76 p.
- Roberts, C. 1979. First year report; cooperative brush control study. Reforestation Consultant. Corvallis, Oregon. 35 p.
- Robinson, G. O. 1975. The Forest Service. Johns Hopkins Press, Baltimore. 283 p.
- Ross, R. 1979. Personal communication. USDA-Forest Service: Range Management. Washington, D. C.
- Sampson, A.W. 1923. Range and pasture management. John Wiley & Sons. New York. 421 p.

- Sandberg, D.V., J.M. Pierovich, D.G. Fox, and E.W. Ross. 1979. Effects of fire on air; a state-of-knowledge review. USDA-Forest Service Gen. Tech. Rept. WO-9. Washington, D.C. 40 p.
- Scifres, C.J. 1979. Integrated brush management systems for rangeland: conceptual utility and practical applications. pp. 13-16, In: R.D. Gale. (Ed.). Proceedings for Integrated Pest Management Colloquim. USDA-Forest Service Gen. Tech. Rept. WO-14. Washington, D.C. 76 p.
- Scifres, C. J. 1978. Range vegetation management with herbicides and alternative methods. pp. 151-165. In: D.E. Ketchum (co-ordinator). Symposium on the use of herbicides in forestry. U.S. Dept. of Agric., Office of the Secretary. Washington, D.C. 213 p.
- Seldon, T. 1979. Personal communication. USDI-Bureau of Reclamation. Washington, D. C.
- Shaw, W. G. 1979. Personal communication. USDA-Science and Education Administration. Washington, D. C.
- Smith, D. M. 1962. The practice of silviculture. Seventh Edition. John Wiley and Sons. New York. 578 p.
- Society of American Foresters. 1978. Herbicide use in forestry; a position of the Society of American Foresters. Washington, D.C. 4 p.
- South, D. B. 1978. Integrated weed management in southern forest nurseries. Proc. Southeast Nursery Conf. Hot Spring, Ak. 10 p.
- Spurr, S. H. and B. V. Barnes. 1973. Forest ecology. 2nd Edition Ronald Press Co., New York. 571 p.
- Stewart, R. E. 1979. Forest systems study. U.S. Dept. of Agric., Forest Service, Timber Management Research. Internal White Paper. Washington, D. C. 14 p. + 3 Figs., 6 tables.
- Stewart, R. E. 1978. Site preparation. p. 100-129. In: B.D. Cleary, R. D. Greaves, and R. K. Hermann (Eds.). Regenerating Oregon's Forests. Ext. Serv. Oreg. State Univ., Corvallis.
- Stewart, R. E. 1976. Herbicides for control of western swordfern and estern bracken. USDA-Forest Service Res. Note PNW-284. USDA-Forest Service, Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 11 p.

- Stoddart, L. A. and A. D. Smith. 1955. Range management. McGraw-Hill Co., New York. 433 p.
- Tarrant, R. F., H. J. Gratkowski, and W. E. Waters. 1973. The future role of chemicals in forestry. USDA-Forest Service Gen. Tech. Rept. PNW-6. USDA-Forest Service, Pacific Northwest Forest and Range Exper. Station. 10 p.
- Towle, E. 1979. Pest management issues. IN: R. D. Gale (Ed.) Proceedings for Integrated Pest Management Colloquium. USDA-Forest Service Gen. Tech. Rept. WO-14. Washington, D.C. 76 p.
- Trevison, A. 1977. Site preparation using heavy equipment. pp. 16-17, In: Proceedings site preparation workshop west. USDA-Forest Service. Atlanta, Ga. 40 p.
- U.S. Department of Agriculture and U.S. Department of Interior. 1966. Chemical control of range weeds. Chemical Plant Control Subcommittee and Range Seeding Equipment Committee. Washington, D.C. 39 p.
- USDA-Forest Service. 1979a. An assessment of the forest and rangeland situation in the United States; Review Draft. U.S. Dept. of Agric., Forest Service. Washington, D.C. 556 p.
- USDA-Forest Service. 1979b. Forest Service research accomplishments/1978. USDA-Forest Service, Washington, D.C. 116 p.
- USDA-Forest Service. 1978a. Evaluation of reforestation and timber stand improvement on the National Forests. U.S. Dept. of Agric., Forest Service. Washington, D.C. 104 p.
- USDA-Forest Service. 1978b. Forest Service research accomplishments/1977. USDA-Forest Service, Washington, D.C. 134 p.
- USDA-Forest Service. 1977. Forest Service research accomplishments/1976. USDA-Forest Service, Washington, D.C. 156 p.
- USDA-Forest Service. 1976a. Forest Service research accomplishments/1975. USDA-Forest Service, Washington, D.C. 148 p.
- USDA-Forest Service. 1976b. Forest Service research accomplishments/1974. USDA-Forest Service, Washington, D.C. 137 p.

- USDA-Forest Service. 1974a. Forest Service research accomplishments/1973. USDA-Forest Service, Washington, D.C. 116 p.
- USDA-Forest Service. 1974b. Environmental statement; rangeland enhancement. USDA-Forest Service, Region 5, San Francisco, California. 139 p.
- USDA-Forest Service. 1972. Forest Service research accomplishments/1972. USDA-Forest Service, Washington, D.C. 179 p.
- USDA-Forest Service. 1971. Research accomplishments 1971. USDA-Forest Service, Washington, D.C. 192 p.
- USDA-Forest Service. 1970. Research accomplishments 1970. USDA-Forest Service, Washington, D.C. 174 p.
- USDA-Forest Service. 1966. Vegetation management for rights-of-way: selective maintenance for improved wildlife habitat and scenic values. USDA-Forest Service Region 9. Milwaukee, Wisconsin.
- USDA, Office of Environmental Quality. 1978. Committees for Environmental Issues. Memorandum. November 20, 1978. Washington, D. C.
- USDA, Office of Environmental Quality. 1979. Draft criteria for evaluating agency IPM programs for development of USDA program. Memorandum. September 17, 1979. Washington, D. C.
- USDA, Office of the Secretary. 1977. Secretary's Memorandum 1929. Washington, D. C.
- USDA, Office of the Secretary. 1979. Memorandum of understanding between Environmental Protection Agency and USDA (as revised). January 19, 1979.
- USDA, Office of the Secretary. 1979. Options for tomorrow. Remarks of M. Rupert Cutler to the Timber Supply Issues and Options Conference. October 3, 1979.
- USDA-States-EPA 2,4,5-T RPAR Assessment Team. 1979. The biologic and economic assessment of 2,4,5-T. USDA-STATES-EPA 2,4,5-T RPAR Assessment Team. Washington, D.C.
- Vallentine, J.F. 1971. Range development and improvements. Brigham Young U. Press. Provo, Utah. 516 p.

- Van Doran, S.W. 1979. Personal communication with David Cottingham. USDA-Forest Service, Washington, D.C.
- Van Strum, S. 1978. Panel discussion. pp. 140-142, In: D.E. Ketchum (coordinator). Symposium on the use of herbicides in forestry. U.S. Dept. of Agriculture, Office of the Secretary. Washington, D.C. 213 p.
- Wells, C.G., R.E. Campbell, L.F. DeBano, C.E. Lewis, R.L. Fredriksen, E. Carlyle Franklin, R.C. Froelich, and P. H. Dunn. 1979. Effects of fire on soil; a state-of-knowledge review. USDA-Forest Service, Gen. Tech. Rept. WO-7. Washington, D.C. 34 p.
- Whiteside, T. 1979. The pendulum and the toxic cloud; the course of dioxin contamination. Yale University Press. New Haven, Conn. 205 p.
- Williams, R.A. 1977. Site preparation for pine regeneration by the use of chemicals. pp. 8-10, In: Proceedings site preparation workshop west. USDA-Forest Service. Atlanta, Ga. 40 p.
- Williams, R.A. 1974. Precommercial thinning. pp. 72-75, In: Proceedings Symposium on management of young pines. USDA-Forest Service. Atlanta, Ga. 349 p.
- Williston, H. 1979. Personal communication. USDA-Forest Service Jackson, Mississippi.
- Witt, J.M. 1978. Classification of silvicultural herbicides. pp. 45-50, In: D.E. Ketchum (coordinator). Symposium on the use of herbicides in forestry. U.S. Dept. of Agric., Office of the Secretary. Washington, D.C. 213 p.
- Young, J.A., R.A. Evans, and R.E. Eckert. 1967. Conversion from weeds to productive grass cover. pp. 200-204, In: Symposium Proceedings: Herbicides and vegetation management in forests, ranges, and noncrop lands. Oregon State Univ., Corvallis. 356 p.

TABLE A-1. Summary of softwood timber demands on and supplies from forests in the contiguous States by timber supply region 1952, 1962, 1970 and 1976 with projections (medium level demand) to 2030 under alternative price assumptions (USDA-Forest Service 1979a:366).

(BILLION BOARD FEET, INTERNATIONAL 1/4 - inch log rule)															
REGION	ITEM	PRICE ASSUMPTIONS													
		1952 ¹	1962 ¹	1970 ¹	1976 ¹	1990	Base Level Prices ²				Equilibrium Prices ³				
		2000	2010	2020	2030	1990	2000	2010	2020	2030	1990	2000	2010	2020	2030
Northeast	Region demand ⁴	1.98	1.48	1.44	1.56	1.53	1.76	2.19	2.68	3.33	1.31	1.51	1.80	2.20	2.69
	Regional supply ⁵	1.98	1.48	1.44	1.56	1.27	1.40	1.57	1.81	2.10	1.31	1.51	1.80	2.20	2.69
	Supply -- demand balance	0	0	0	0	-.26	-.36	-.62	-.87	-1.23	0	0	0	0	0
North Central	Regional demand ⁴	.50	.58	.59	.46	.95	1.17	1.46	1.78	2.16	.82	1.00	1.19	1.45	1.74
	Regional supply ⁵	.50	.58	.59	.46	.91	1.01	1.10	1.23	1.40	.82	1.00	1.19	1.45	1.74
	Supply -- demand balance	0	0	0	0	-.04	-.16	-.36	-.55	-.76	0	0	0	0	0
Southeast	Regional demand ⁴	6.69	4.99	5.54	6.88	11.05	13.07	15.42	16.79	17.54	9.35	10.80	12.20	13.09	13.41
	Regional supply ⁵	6.69	4.99	5.54	6.88	8.26	10.27	12.35	13.82	14.32	9.35	10.88	12.20	13.09	13.41
	Supply -- demand balance	0	0	0	0	-2.79	-2.80	-3.07	-2.97	-3.22	0	0	0	0	0
South Central	Regional demand ⁴	5.64	4.30	9.60	11.79	15.32	17.99	21.39	23.56	24.11	12.72	14.69	16.48	17.51	17.39
	Regional supply ⁵	5.64	4.30	9.60	11.79	11.80	13.51	14.99	16.19	17.09	12.72	14.69	16.48	17.51	17.39
	Supply -- demand balance	0	0	0	0	-3.52	-4.48	-6.40	-7.37	-7.02	0	0	0	0	0
Rocky Mountains and Great Plains	Regional demand ⁴	2.57	4.15	5.40	4.74	6.19	6.09	6.29	6.24	6.28	4.90	4.76	4.68	4.62	4.60
	Regional supply ⁵	2.57	4.15	5.40	4.74	4.93	5.43	5.75	5.96	6.05	4.90	4.76	4.68	4.62	4.60
	Supply -- demand balance	0	0	0	0	-1.26	-.66	-.54	-.28	-.23	0	0	0	0	0
Pacific Northwest ⁶ Douglas-fir Subregion (Western Washington and Western Oregon)	Regional demand ⁴	12.78	14.44	15.00	15.30	17.70	16.63	16.58	15.41	14.65	14.50	13.18	12.31	11.24	10.41
	Regional supply ⁵	12.78	14.44	15.00	15.30	14.61	13.11	12.02	11.17	10.51	14.50	13.18	12.31	11.24	10.41
	Supply -- demand balance	0	0	0	0	-3.09	-3.52	-4.56	-4.24	-4.14	0	0	0	0	0
Ponderosa Pine subregion (Eastern Washington and Eastern Oregon)	Regional demand ⁴	2.15	2.66	3.54	3.47	4.45	4.42	4.67	4.56	4.57	3.60	3.52	3.52	3.44	3.40
	Regional supply ⁵	2.15	2.66	3.54	3.47	3.67	3.55	3.51	3.43	3.41	3.60	3.52	3.52	3.44	3.40
	Supply -- demand balance	0	0	0	0	-.78	-.87	-1.16	-1.13	-1.16	0	0	0	0	0
Pacific Southwest ⁷	Regional demand ⁴	5.99	6.10	5.59	5.70	6.91	6.47	6.60	6.28	6.06	5.37	4.90	4.67	4.38	4.15
	Regional supply ⁵	5.99	6.10	5.59	5.70	4.78	4.45	4.36	4.35	4.37	5.37	4.90	4.67	4.38	4.15
	Supply -- demand balance	0	0	0	0	-2.13	-2.02	-2.24	-1.93	-1.69	0	0	0	0	0

¹Data are estimates of actual consumption, of harvests and differ somewhat from the "trend" estimates shown in the following section on timber supplies.

²Projections show timber demand on, supply from, U.S. forest assuming that the price trends in the base period used in making the projections (roughly from the late 1950's through the mid-1970's) continue through the projection period.

³Projections show timber demand on, supply from, U.S. forest assuming that prices rise enough to maintain an equilibrium between projected demand and supply.

⁴Demand for products converted to a round wood equivalent basis. The projections include adjustments for increased product yield per unit of round wood input which are expected to result from improvements in utilization.

⁵The base level projections show the volume of timber available for harvest from regional forests if recent trends in the forces determining supply, such as commercial timberland area, management and prices continue through the projection period.

⁶Excludes Alaska.

⁷Excludes Hawaii.

NOTE: Data may not add to totals because of rounding.

TABLE A-2. Average net annual and potential growth per acre in the United States, by ownership, and section, 1976^{1/}

Section	Units of measure	All ownerships	National Forest	Other public	Forest industry	Farmer and other private
North:						
Current	cubic feet	35.1	42.2	37.9	45.2	32.2
Potential	cubic feet	66.3	62.3	59.3	74.5	66.6
Current potential	percent	53.0	68.0	64.0	61.0	48.0
South:						
Current	cubic feet	56.0	58.9	55.5	61.0	54.6
Potential	cubic feet	76.1	70.6	70.5	82.4	75.3
Current potential	percent	74.0	83.0	79.0	74.0	73.0
Rocky Mountains and Great Plains:						
Current	cubic feet	28.7	30.4	34.5	49.9	23.4
Potential	cubic feet	59.5	63.6	54.4	74.0	49.6
Current potential	percent	48.0	48.0	63.0	67.0	47.0
Pacific Coast:						
Current	cubic feet	48.5	30.3	50.9	73.8	64.7
Potential	cubic feet	96.8	90.7	88.3	118.0	99.5
Current potential	percent	50.0	33.0	58.0	63.0	65.0
Total:						
Current	cubic feet	44.8	35.4	42.1	58.9	44.9
Potential	cubic feet	73.9	74.0	68.1	86.6	71.8
Current potential	percent	61.0	48.0	62.0	68.0	63.0

^{1/} Potential growth is defined as the average net growth attainable in fully stocked natural stands. Higher growth rates can be attained in intensively managed stands.

SOURCE: USDA-Forest Service 1979a:317.

TABLE A-3. Number of Forest Service research reports¹ on the use of herbicides as one method of site preparation.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	OTHER	TOTAL
1978 ²	-	-	-	4	-	1	-	1	-	-	-	6
1977 ²	-	-	-	2	-	-	-	2	-	-	-	4
1976	-	-	2	1	-	-	-	1	-	-	-	4
1975	-	-	3	3	-	-	-	3	-	-	-	9
1974	1	-	1	3	-	-	-	3	-	-	-	8
1973	-	-	2	1	-	-	2	1	-	-	-	6
1972 ³	1	-	-	-	3	-	-	3	-	-	-	7
1971 ³	1	-	1	-	-	-	-	1	-	-	-	3
1970 ³	-	-	-	-	1	-	-	-	-	-	3	4
TOTAL	3	0	9	14	4	1	2	15	0	0	3	51

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles when no abstracts were available.

TABLE A-4. Properties of herbicides used in forestry (USDA-States-EPA-2,4,5-T RPAR Assessment Team 1979)

HERBICIDE	FORMULATION	APPLICATION ^a RATE	SELECTIVITY	ROUTE OF UPTAKE	COST ^b (\$/lb ai or \$/gal)
Fosamine	Krenite-water soluble liquid ^b liquid ^b	1-1/2 to 3 gal/A 300/gal/gal/A ground in water	Deciduous species for site preparation	Foliage	\$32/gal
Anitrole-T	Amino triazole + ammonium thiocyanate liquid ^{b,c}	1/2 to 1	Salmonberry and elderberry; will damage Douglas if applied too early or late	Foliage	\$13/gal
Asulam	Asulam-sodium salt liquid	1 gal/A	Bracken fern; use on Christmas trees when not actively growing	Foliage	\$38/gal
Atrazine	80% wettable powder ^{b,c}	3 to 4 lb ai/A ^b	Annual grasses and some forbs does not damage conifers when properly applied	Root	\$2.80/lb
Cacodylic acid	Dimethylarsinic acid	Undiluted	Hardwoods and conifers by injection	Cut surface	\$3.70/lb
Dalapon	74% sodium and magnesium salts- water soluble ^{b,c}	3 to 11 lb ai/A	Annual and peren- nial grasses for site preparation use with atra- zine or directed sprays for release	Foliage and root	\$1.96/lb

TABLE A-4, cont.

HERBICIDE	FORMULATION	APPLICATION ^a RATE	SELECTIVITY	ROUTE OF UPTAKE	COST ^b (\$/lb ai or \$/gal)
Picloram	Triisopropano- lamine salts to picloram & 2,4-D (Tordon 101R and Tordon 101) ^d	Undiluted	Hardwoods and conifers by injection	Cut surface	\$10/lb for Tordon 101R and \$17.50/ gal for Tor- don 101
Picloram	Triisopropano- lamine salts of picloram & 2,4-D (Tordon 101) with or w/o low vola- tile esters of 2,4,5-T or silvex ^a	1 to 4 gal/A	Shrubs and weed trees for site preparation	Foliage	\$17.50/gal
	Isooctyl ester of picloram & PGBE ester of 2,4,5-T (Tordon 155)	1/2 to 1 gal/A	Shrubs and weed trees for site preparation	Stem	\$49/gal
Pronamide	50% wettable powder	1 to 2 lb/A	Grasses only for site preparation or releases in Christmas trees	Root	\$13/lb
Dicamba	Dimethylamine salt ^d	Undiluted or 1:4 in water	Hardwoods and conifers by injection	Cut Surface	\$34/gal
	Dimethylamine salts of dicamba & 2,4-D or 2,4,5-T	1 to 3 gal/A	Shrubs and weed trees for site preparation	Foliage	\$13 to \$18/gal
	Oil-soluble acid of dicamba and isooctyl esters of 2,4-D or 2,4,5-T	1 gal/A	Shrubs and weed trees for site preparation	Stem	\$17 to \$20/gal

TABLE A-4, cont.

HERBICIDE	FORMULATION	APPLICATION ^a RATE	SELECTIVITY	ROUTE OF UPTAKE	COST ^b (\$/lb ai or \$/gal)
DNBP	Emulsifiable dinitrophenol	1 to 2 gal/A	Nonselective, nontranslocated desiccant used to prepare herba- ceous & woody vegetation for burning	Foliage	\$8/gal
MSMA	Monosodium acid methanearsonate ^d	Undiluted	Hardwoods and conifers by injection	Cut Surface	\$12.35/gal
Picloram	Potassium salt + invert emulsions of 2,4-D or 2,4,5-T ^b	1 to 4 quarts picloram + 1 to 4 gal of phenoxy invert	Shrubs and weed trees for site preparation	Foliage	\$60/gal + invert
Triclopyr	Amine salt, water soluble	2-4 lb/A	Deciduous and evergreen brush. Injurious to conifers during elongation	Foliage	\$45/gal.
Silvex	Low-volatile esters (BEE, PGBE) ^{b,c}	1/4 to 3/4 gal/A	Shrubs, weed trees and forbs; slightly more damaging to con- ifers than 2,4-D or 2,4,5-T	Stems and foliage	\$18/gal at 4 lb ae/gal
Simazine	80% wettable powder	3 to 4 lb/A	Annual grasses and some forbs for site preparation and release in Christmas trees	Root	\$3.06/lb
2,4-D	Amined ^d	Undiluted or 1:1 with water	Hardwoods except cherry and big- maple by injec- tion	Cut Surface	\$6.50 at 4 lb ae/gal

TABLE A-4, cont.

HERBICIDE	FORMULATION	APPLICATION ^a RATE	SELECTIVITY	ROUTE OF UPTAKE	COST ^b
2,4-D	Low volatile ester (Isooctyl, BEE, PGBE) ^{b,c}	1/4 to 3/4 gal/A	Shrubs, weed trees and forbs for site preparation and conifer release (except pines)	Stem and Foliage	\$8/gal at 4 lb ae/gal
2,4,5-T	Low-volatile ester (Isooctyl, BEE, PGBE) ^{b,c}	1/4 to 3/4 gal/A	Shrubs, weed trees and forbs, for site preparation and release	Stem and Foliage	\$17/gal at 4 lb ae/gal
	Amined ^d	Undiluted of 1:1 with water	Hardwoods by injection	Cut Surface	\$19/gal at 4 lb ae/gal
Velpar	Granular hexazinone	1 lb ae/acre	Hardwoods	Roots	\$15/lb
Glyphosate	Isopropylamine salt water soluble ^b	1/4 to 3/8 gal/A	Deciduous woody species and herbs for site preparation and release	Foliage	\$60/gal

^a ae - acid equivalent; ai - active ingredient.

^b Site preparation herbicides most commonly used.

^c Release herbicides most commonly used.

^d Thinning herbicides most commonly used

TABLE A-5. Number of Forest Service research reports¹ on prescribed fire as one method for site preparation.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	OTHER	TOTAL
1978 ²	4	-	-	1	2	-	1	-	-	-	-	8
1977 ²	6	-	2	3	-	-	1	1	-	-	-	13
1976	1	-	2	-	-	2	1	1	-	-	-	7
1975	-	1	3	-	1	-	-	-	-	-	-	5
1974	2	-	5	1	-	-	1	-	-	-	-	9
1973	1	-	6	1	1	-	5	-	-	-	-	14
1972 ³	1	-	1	3	2	1	1	1	-	-	-	10
1971 ³	1	-	2	-	1	-	3	1	-	-	-	8
1970 ³	3	-	1	-	1	-	2	-	-	-	8	15
TOTAL	19	1	22	9	8	3	15	4	0	0	8	89

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these reports. A greater degree of speculation was required to categorize articles when no abstracts were available.

TABLE A-6. Number of Forest Service research reports¹ on mechanical treatment as one method for site preparation.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	OTHER	TOTAL
1978 ²	-	-	-	1	-	-	-	2	-	-	-	3
1977 ²	-	-	-	-	-	-	-	1	-	-	-	1
1976	-	-	3	1	-	1	1	2	-	-	-	9
1975	-	-	-	-	-	-	1	4	-	-	-	5
1974	1	-	-	1	2	-	5	2	-	-	-	11
1973	-	2	3	-	-	-	2	2	-	-	-	9
1972 ³	2	-	1	-	1	1	1	2	-	-	-	8
1971 ³	1	1	2	-	-	-	-	3	-	-	-	7
1970 ³	2	-	1	-	-	1	-	1	-	-	1	6
TOTAL	7	3	10	3	3	3	10	19	0	0	1	59

¹ Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

² No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³ Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

TABLE A-7. Number of Forest Service research reports¹ on the use of herbicides for release.

EXPERIMENT STATIONS:											
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	TOTAL
1978 ²	-	-	-	4	-	-	-	1	-	-	5
1977 ²	-	-	-	6	-	-	-	1	-	-	7
1976	-	-	-	1	-	-	-	2	-	-	3
1975	-	-	-	5	-	-	-	3	-	-	8
1974	-	1	-	4	-	-	-	5	-	-	10
1973	-	-	2	1	-	-	-	1	-	1	5
1972 ³	-	-	-	1	-	-	-	3	-	-	4
1971 ³	-	1	2	-	1	-	1	2	-	-	7
1970 ³	-	-	-	-	1	-	-	-	-	-	1
TOTAL	0	2	4	22	2	0	1	18	0	1	50

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles when no abstracts were available.

TABLE A-8. Number of Forest Service research reports¹ on the use of prescribed fire for release.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	OTHER	TOTAL
1978 ²	2	-	-	-	1	-	1	1	-	-	-	5
1977 ²	3	-	-	1	-	-	2	3	-	-	-	9
1976	-	-	-	-	-	-	1	2	-	-	-	3
1975	-	1	6	3	1	-	1	1	-	-	-	13
1974	-	-	4	1	1	-	1	2	-	-	-	9
1973	-	-	5	-	1	-	4	1	-	-	-	11
1972 ³	1	-	1	-	1	-	3	-	-	-	-	6
1971 ³	1	-	2	-	-	-	5	1	-	-	-	9
1970 ³	1	-	1	-	1	-	1	-	-	-	7	11
TOTAL	8	1	19	5	6	0	19	11	0	0	7	76

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles when no abstracts were available.

TABLE A-9. Number of Forest Service research reports¹ on the use of individual stem treatment of herbicides for thinning.

Year	EXPERIMENT STATIONS										TOTAL
	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	
1978 ²	2	-	-	1	-	-	2	-	-	-	5
1977 ²	-	-	-	-	-	-	-	1	-	-	1
1976	-	1	-	-	-	-	-	1	-	-	2
1975	-	1	-	-	-	-	-	1	-	-	2
1974	-	-	-	1	1	-	-	-	-	-	2
1973 ³	-	-	-	-	-	-	-	4	-	-	4
1972 ³	-	-	-	-	-	-	-	2	-	-	2
1971 ³	-	-	-	1	-	-	-	1	-	-	2
1970 ³	-	-	-	-	-	-	-	-	-	-	-
TOTAL	2	2	-	3	1	-	2	10	-	-	20

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculations was required to categorize articles when no abstracts were available.

TABLE A-10. Number of Forest Service research reports¹ on the use of mechanical treatments for thinning.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	OTHER	TOTAL
1978 ²	1	-	-	1	-	-	2	1	-	-	-	5
1977 ²	-	-	3	-	-	-	-	1	-	-	-	4
1976	-	-	1	-	-	-	-	1	-	-	-	2
1975	-	-	-	1	-	-	-	2	-	-	-	3
1974	-	-	-	-	-	-	-	1	-	-	-	1
1973	-	-	-	-	-	-	2	3	-	-	-	5
1972 ³	-	-	-	-	-	-	-	1	-	-	-	1
1971 ³	-	-	1	-	-	-	-	1	-	-	-	2
1970 ³	-	-	1	-	1	-	-	-	-	-	2	4
TOTAL	1	0	6	2	1	0	4	11	0	0	2	27

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles when no abstracts were available.

TABLE A-11. Induced progression by manipulation of factors in range ecosystems (Vallentine 1971).

Factors	Manipulation
Controlling factors Climatic elements Geological material	Weather modification, burning waterspreading, land leveling, terracing, fertilization, ground water recharge, drainage
Available organisms plants and animals)	Species introduction, elimina- tion, and genetic improvement
Dependent factors Consumers	
Wild fauna	Grazing management, wildlife management, insect and rodent control
Livestock	Grazing management (through handling facilities), livestock management
Vegetation	Plant control, revegetation, hay management, plant disease control
Soil	Mechanical treatments, nitrogen fertilization
Decomposers and transformers	Direct manipulation probably not feasible
Microclimate	Shades, shelters, mulch manipulation

TABLE A-12. Condition of rangeland ecosystems in the United States 1976¹ (Source: USDA-Forest Service, 1979).

(Thousand Acres)

ECOSYSTEM	TOTAL	HIGH	MODERATELY HIGH	MODERATELY LOW	LOW
Contiguous States:					
Grasslands					
Mountain grasslands	26,871	4,705	9,725	8,392	4,049
Mountain meadows	3,285	1,063	1,276	692	254
Plains grasslands	175,233	25,808	59,878	69,373	20,177
Prairie	41,185	5,740	14,097	15,695	5,653
Desert grasslands	24,744	2,086	6,109	12,483	4,066
Wet grasslands	4,408	748	1,218	911	1,531
Annual grasslands	10,153	1,336	510	3,731	4,576
Alpine	6,775	2,897	1,835	1,948	95
TOTAL	292,654	44,382	94,645	113,225	40,401
Shrublands					
Sagebrush	129,961	16,023	46,826	45,602	21,510
Desert shrub	81,171	14,130	29,581	25,547	11,913
Shinnery	4,726	780	1,307	1,915	724
Texas savanna	28,429	4,666	6,689	13,037	4,037
Southwestern shrubsteppe	43,218	4,535	6,398	17,925	14,359
Chapparal-mountain shrub	14,120	1,654	3,083	5,442	3,941
Pinyon-juniper	47,304	4,285	13,509	21,012	8,498
Desert	7,490	5,739	865	486	400
TOTAL	356,419	51,812	108,258	130,967	65,382
TOTAL 48 STATES	649,073	96,194	202,904	244,192	105,783
Alaska					
Muskeg-bog	14,383	14,383	0	0	0
Shrub thickets	17,762	14,853	2,023	886	0
Moist tundra	66,576	40,344	22,902	3,330	0
Wet tundra	26,256	26,256	0	0	0
Alpine tundra	103,114	85,069	18,045	0	0
Aleutian moist tundra	1,215	850	365	0	0
Aleutian alpine	2,165	1,517	541	107	0
TOTAL	231,471	183,272	43,876	4,323	0
Hawaii					
Forest-shrub-grass mosaic	493	72	72	95	254
Koa-mamami-parkland	250	117	58	73	2
Grass-shrub-barren mosaic	225	154	36	30	5
TOTAL	968	343	166	198	261
TOTAL UNITED STATES	881,512	279,809	246,945	248,713	106,044

1/ For definition of condition class, see text. These data were extracted verbatim from the 1979 Forest Service RPA Assessment. Although mistakes in addition were noted, it was felt to be inappropriate to correct them.

TABLE A-12. (continued)

DEFINITION:

<u>Condition Class</u>	<u>Standards used</u>
1. High	Vegetation and soils deviate from site potential by less than 40 percent
2. Moderately high	Vegetation and soils deviate 40 to 59 percent from potential
3. Moderately low	Vegetation and soils deviate 60 to 79 percent from potential
4. Low	Vegetation and soils deviate by 80 percent or more from potential

¹These data were extracted verbatim from the 1979 Forest Service RPA Assessment. Although mistakes in addition were noted, it was felt to be inappropriate to correct them.

TABLE A-13. Percent and number of acres of range brush management accomplished with prescribed fire
(Source: USDA-Forest Service Regional estimates).

YEAR		REGION;								TOTAL
		1	2	3	4	5	6	8	9	
1978	Percent	94.9	6.0	32.2	32.5	24.3	5.1	100.0	0	62.7
	Acres	2,810.7	371.0	3,900.0	6,958.0	1,000.0	279.0	27,707.0	0	43,025.7
1972 ¹	Percent	42.9	0	0	2.6	0	0	87.0 ²	0	8.4
	Acres	1,776.0	0	0	1,123.1	0	0	2,948.1 ²	0	5,847.2
1971 ¹	Percent	0	0	0 ²	0	0	0	98.3 ²	0	6.2
	Acres	0	0	0 ²	0	0	0	3,827.2 ²	0	3,827.2
1970 ¹	Percent	0	0	0 ²	0	0	0	99.6	0	13.1
	Acres	0	0	0	0	0	0	11,345.5	0	11,345.5
1969 ¹	Percent	0	0	0	0	0	0	88.3 ²	0	8.1
	Acres	0	0	0	0	0	0	7,720.0 ²	0	7,720.0
MEAN PERCENT		10.7	1.2	6.4	7.0	4.8	1.0	94.6	0	19.7

¹Estimated by totaling yearly data for plant control (seeded), plant control (not seeded) and poison plant control, and dividing by percentage of total vegetation management which is brush management as determined by 1978 data.

²Exclusive of considerable acreage which was prescribed burned for unknown reasons. Additional acreage described as "prescribed burn":

R-3; 1970 - 8,720 A
R-3; 1971 - 12,000 A
R-8; 1969 - 97,692 A

R-8; 1970 - 100,121 A
R-8; 1971 - 79,195 A
R-8; 1972 - 55,567 A

TABLE A-14. Number of Forest Service research reports¹ on the use of fire as a method for weed management on rangelands.

EXPERIMENT STATIONS:										
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	UNKNOWN
1978 ²	1	-	-	-	2	5	1	1	-	-
1977 ²	-	-	1	1	-	3	1	1	-	-
1976	-	-	-	-	-	1	1	1	-	-
1975	3	-	-	1	1	-	1	-	-	-
1974	4	-	-	-	1	2	-	3	-	-
1973	3	-	-	1	-	-	-	-	-	-
1972 ³	-	-	1	-	1	3	-	1	-	-
1971 ³	-	-	-	-	-	-	-	-	-	-
1970 ³	1	-	-	-	1	1	-	-	-	1
TOTAL	12	0	2	3	6	15	4	7	0	1

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles without abstracts.

TABLE A-15. Number of species of range brush for which various herbicides are recommended (Source: U. S. Department of Agriculture and U. S. Department of Interior, 1966).

<u>Herbicide</u>	<u>No. of recommended species</u>
Ammonium sulfamate	2
Argenite	1
DNDP	1
Dalapon	1
Dicamba	1
Dichloroprop	2
Fenuron	6
Fenuron & TCA	1
MCPA	1
Monuron	4
PBA	1
Picloram	5
Silvex	5
TBA	1
TCA	3
2,4-D	13
2,4,5-T	13
2,4-D & 2,4,5-T	4

TABLE A-16. Herbicides used on range considering method of application, selectivity, and type of action. (Vallentine 1971:119)

- I. Foliage spray application--broadcast or individual plant.
 - A. Selective
 - 1. Translocated--2,4-D*, 2,4-DB, 2,4-DP, 2,4,5-T*, silvex, MCPA, dalapon, dicamba, TCA, picloram.
 - 2. Contact--DNBP salt (unimportant in range improvement).
 - B. Nonselective
 - 1. Translocated--AMS, amitrol.
 - 2. Contact--diquat and paraquat (effect generally low on broadleaf plants), PCP, DNBP, kerosene and diesel oil.
- II. Foliage dust application--unimportant in range improvement.
- III. Individual trunk treatment (special woody plant applications).
 - A. Trunk base spray--2,4,5-T*, picloram, silvex.
 - B. Frills--AMS, 2,4,5-T*, 2,4-D amine*.
 - C. Trunk injection--2,4,5-T*, picloram, 2,4-D amine*.
 - D. Cut-stump Treatment--AMS, 2,4,5-T*, 2,4-D amine*.
- IV. Soil application (temporary sterilization)--including spray, pellet, or granular application or by soil injection--atrazine, bromacil, dicamba, diuron, fenuron, monuron, fenac, TBA, PBA, picloram, TCA, borax.

*USDA-Forest Service policies listed significant restrictions for the use of these herbicides.

TABLE A-17. Percent and number of acres of range brush management accomplished with chemical herbicides applied using broadcast methods (Source: USDA-Forest Service Regional estimates).

		REGION:								TOTAL
YEAR		1	2	3	4	5	6	8	9	
1978	Percent	0	78.9	0	32.5	75.7	93.7	0	0	24.8
	Acres	0	4,853.0	0	6,966.0	3,111.7	5,122.0	0	0	20,052.7
1972 ¹	Percent	56.6	62.9	6.6	56.6	52.0	91.8	12.4	0	48.0
	Acres	2,343.7	4,342.1	984.3	20,124.7	6,346.6	6,121.4	418.8	0	40,681.6
1971 ¹	Percent	100.0	61.1	11.5	68.2	55.6	90.3	0	0	44.3
	Acres	2,639.7	3,704.9	4,346.1	25,891.4	3,221.5	4,386.1	0	0	44,189.7
1970 ¹	Percent	97.8	79.9	24.9	69.7	0	91.0	0	0	47.3
	Acres	5,654.2	9,222.6	9,334.1	29,758.8	0	4,801.4	0	0	58,771.1
1969 ¹	Percent	100.0	65.5	20.6	77.3	67.0	99.7	0	0	55.2
	Acres	11,056.2	9,679.3	10,508.6	27,902.4	4,175.9	17,670.4	0	0	80,992.8
MEAN PERCENT		70.9	69.7	12.7	60.9	50.0	93.3	2.5	0	43.9

¹Estimated by totaling yearly data for plant control (seeded), plant control (not seeded), and poison plant control, and dividing by percentage of total vegetation management which is brush management as determined by 1978 data.

TABLE A-18. Percent and number of acres of range brush management accomplished with chemical herbicides applied using selective methods (Source: USDA-Forest Service Regional estimates).

YEAR		REGION: 1	2	3	4	5	6	8	9	TOTAL
1978	Percent	0	0	0	0	0	0	0	0	0
	Acres	0	0	0	0	0	0	0	0	0
1972 ¹	Percent	0	0.6	0	0.9	33.0	1.6	0	0	5.3
	Acres	0	43.9	0	303.3	4,028.7	109.0	0	0	4,484.9
1971 ¹	Percent	0	0	0	2.8	0.5	0	1.7	1.2	1.2
	Acres	0	0	0	1,079.4	31.8	0	65.6	9.4	1,186.2
1970 ¹	Percent	0	0.1	0	2.1	43.9	0.1	0	0	3.9
	Acres	0	15.5	0	916.0	3,878.7	4.5	0	0	4,814.7
1969 ¹	Percent	0	1.3	0.2	5.5	0.9	0.3	0	0	1.6
	Acres	0	193.5	104.6	1,974.4	59.1	54.1	0	0	2,385.7
MEAN PERCENT		0	0.4	<0.1	2.3	15.7	0.4	0.3	0.2	2.4

¹Estimated by totaling yearly data for plant control (seeded), plant control (not seeded), and poison plant control, and dividing by percentage of total vegetation management which is brush management as determined by 1978 data.

TABLE A-19. Number of Forest Service research reports¹ on the use of herbicides applied using broadcast methods, as a treatment for weed management on rangelands.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	OTHER	TOTAL
1978 ²	-	-	-	-	-	-	-	-	-	-	-	0
1977 ²	-	-	-	-	-	-	-	-	-	-	-	0
1976	1	-	-	-	-	4	-	1	-	-	-	6
1975	-	-	-	1	-	2	-	-	-	-	-	3
1974	-	1	-	1	-	2	-	2	-	-	-	6
1973	-	-	-	-	-	-	-	-	-	-	-	0
1972 ³	-	-	-	-	-	2	-	-	-	-	-	2
1971 ³	-	-	-	-	-	1	-	-	-	-	-	1
1970 ³	-	-	-	-	-	-	-	-	-	-	1	1
TOTAL	1	1	0	2	0	11	0	3	0	0	1	19

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for an article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles when abstracts were unavailable.

TABLE A-20. Comparison of mechanical equipment used in seedbed preparation on rangeland (Vallentine 1971:244-245).

EQUIPMENT	AREAS SUITABLE	DISADVANTAGES
PIPE HARROW	Adapted to rocky and steep sites where more effective machinery is not adapted. Also, scarifies soil sufficient for covering broadcasted seed on burns, abandoned roads, or excavation scars.	Low kill of large shrubs, sprouting or willowy plants, and most herbaceous plants; may not clean itself, brings many rocks to the surface; and must be disassembled before transporting.
MOLDBOARD PLOW	Widely used on cultivated soils that are rock free, dense, and tight, but seldom on range.	Slow; high power per width of cut; high cost; ineffective on hard sticky or rocky soil; picks up roots and trash; tolerates only very small brush.
PITTING	Many types available, including pitting disk plow with cut-away or eccentric disks. Adapted to medium-heavy textured soils on deteriorated range, go-back lands, and areas of low precipitation. Pits trap snow and water and protect young seedlings.	Does not reduce dense, perennial sod, rhizomatous plants or brush sufficiently for good seedling establishment. Must often be preceded by plowing.
RAILING	Adaptation very limited for seedbed preparation.	Ineffective on herbaceous plants and limber or sprouting shrub species; insufficient soil scarification for adequate coverage of previously broadcasted seed except on sandy soil.
CHAINING & CABLING	Adapted to large, nonsprouting brush such as juniper and mature big sagebrush and on areas too rocky, rough or steep for other equipment. Low cost per acre. Used on large acreages where total destruction of understory vegetation is undesirable.	Low kill of sprouting brush and understory species. Seeding limited to broadcasting prior to final chaining. Special equipment needed for loading and transporting chain.
BULLDOZING	Generally unadapted as sole treatment in seedbed preparation except where used for blading into windrows. Often preceded by chaining or followed by other treatments such as chaining or plowing for final seedbed preparation.	Leaves seedbed very rough; costly in complete land treatment; maximum soil disturbance; generally requires additional treatments such as piling brush, plowing, or subsequent chaining of cleared areas.
STANDARD DISK PLOW	Adapted to deep soils free of rocks. Will penetrate hard soils and withstand sticky soils.	High cost per acre; slow; loosens soil too much; high breakage on range; narrow cut and high draft.
WHEATLAND PLOW	Adapted to gentle terrain with nearly rock-free, moderately soft soil; frequently used on land previously cultivated and for light tillage in second time over. Commercially available. Plowing depths readily adjusted on even terrain.	High breakage on rough, rocky, brushy sites; often plows too shallow, second time over generally required.

TABLE A-20 , cont.

BRUSHLAND PLOW	Adapted to brush up to 2" in diameter, hard soil, uneven terrain, rocks, and stumps with low breakage. More effective than wheatland plow on uneven, rocky sites. High kill with single treatment.	High initial cost; difficult to transport; heavy draft; may leave seedbed too soft; not commercially available.
OFFSET DISK	Heavy models adapted to most areas not too rocky. Commercially available. Adapted to hard, dry, heavy soils. Cutaway disks do a better job of mulching the vegetation. High kill with once-over treatment.	Difficult to regulate plowing depth, particularly on sandy or loose soils; difficult to transport; seedbeds often too loose without packing by other equipment; leaves dead furrows that may induce water erosion; drafty.
ROOT PLOW	Adapted to deep, rock-free soils with brush too large or too dense for other equipment.	Not adapted to shallow, rocky, rough, steep, or muddy sites. High initial cost and drafty. Rhizomes of sprouting species must be worked to the surface to prevent sprouting. Seedbed generally too soft for successful seeding until after loose, open soil has been compacted.

TABLE A-21. Percent and number of acres of range brush management accomplished with mechanical methods (Source: USDA-Forest Service Regional estimates).

YEAR		REGION: 1	2	3	4	5	6	8	9	TOTAL
1978	Percent	0	15.0	67.8	35.0	0	1.2	0	19.6	20.9
	Acres	0	925.0	8,200.0	7,514.0	0	65.0	0	153.0	16,857.0
1972 ¹	Percent	0.5	36.4	44.1	44.5	14.9	5.6	0	99.2	33.5
	Acres	20.7	2,512.1	6,620.8	15,833.4	1,818.0	371.2	0	1,196.2	28,372.4
1971 ¹	Percent	0	38.9	88.5	28.9	43.8	9.7	0	98.8	50.6
	Acres	0	2,357.3	33,397.2	10,972.2	2,537.0	468.5	0	750.8	50,483.0
1970 ¹	Percent	2.2	20.0	75.1	28.1	56.1	8.5	0	98.9	39.6
	Acres	125.5	2,304.8	28,107.8	12,014.0	4,962.2	450.5	0	1,183.5	49,148.3
1969 ¹	Percent	0	33.2	79.2	17.3	32.0	0	5.5	97.4	37.5
	Acres	0	4,902.0	40,351.8	6,234.2	1,995.3	0	482.5	1,147.3	55,113.1
MEAN PERCENT		0.5	28.7	70.9	30.8	29.4	5.0	1.1	82.8	36.4

¹Estimated by totaling yearly data for plant control (seeded), plant control (not seeded), and poison plant control, and dividing by percentage of total vegetation management which is brush management as determined by 1978 data.

TABLE A-22. Number of Forest Service research reports¹ on mechanical methods as treatment for weed management on rangelands.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	UNKNOWN	TOTAL
1978 ²	-	-	-	-	-	-	-	-	-	-	-	0
1977 ²	-	-	-	-	-	-	-	-	-	-	-	0
1976	1	-	-	-	-	-	-	-	-	-	-	1
1975	-	-	-	-	-	2	-	-	-	-	-	2
1974	-	-	-	-	-	1	-	-	-	-	-	1
1973	1	-	-	-	-	1	1	1	-	-	-	4
1972 ³	-	-	-	-	-	-	-	-	-	-	-	0
1971 ³	-	-	-	-	-	1	1	-	-	-	-	2
1970 ³	-	-	-	-	-	-	-	-	-	-	1	1
TOTAL	2	0	0	0	0	5	2	1	0	0	1	11

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by title.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles without abstracts.

TABLE A-23. Percent and number of acres of range brush management accomplished with seeding (Source: USDA-Forest Service Regional estimates).

YEAR		REGION: 1	2	3	4	5	6	8	9	TOTAL
1978	Percent	5.1	0	49.2	35.0	0	3.0	0	0	17.1
	Acres	150.0	0	5,950.0	7,514.0	0	164.0	0	0	13,778.0
1972 ¹	Percent	0.5	36.4	5.5	44.5	32.4	18.3	86.9	76.9	33.3
	Acres	20.7	2,512.1	821.7	15,833.4	3,954.1	1,219.1	2,948.1	919.3	28,228.5
1971 ¹	Percent	0	15.0	37.8	28.9	43.8	41.8	1.7	62.4	31.3
	Acres	0	908.2	14,265.0	10,972.2	2,537.0	2,027.2	65.6	474.5	31,249.7
1970 ¹	Percent	2.2	0	51.2	28.1	57.4	45.1	0	55.1	31.7
	Acres	125.5	0	19,156.2	12,014.0	5,073.1	2,381.3	0	658.0	39,408.1
1969 ¹	Percent	0.3	24.6	72.9	17.3	32.0	24.5	0	61.4	36.9
	Acres	35.5	3,640.7	37,175.5	6,234.2	1,995.3	4,343.7	0	723.3	54,148.2
MEAN PERCENT		1.6	15.2	43.3	30.8	33.1	26.5	17.7	51.2	30.1

¹Estimated by totaling yearly data for plant control (seeded), plant control (not seeded), and poison plant control, and dividing by percentage of total vegetation management which is brush management as determined by 1978 data.

TABLE A-24. Number of Forest Service research reports¹ on seeding as a treatment for weed management on rangelands.

EXPERIMENT STATIONS:												
YEAR	INT	NE	NC	PNW	PSW	RM	SE	SO	FPL	WO	UNKNOWN	TOTAL
1978 ²	-	-	-	-	1	-	-	-	-	-	-	1
1977 ²	-	1	-	-	-	-	-	-	-	-	1	2
1976	2	-	-	-	-	-	-	1	-	-	-	3
1975	1	-	-	1	-	2	-	1	-	-	-	5
1974	3	-	-	-	-	-	-	-	-	-	-	3
1973	-	-	-	1	-	2	-	-	-	-	-	3
1972 ³	-	-	-	-	-	2	-	-	-	-	1	3
1971 ³	-	-	-	-	-	8	1	-	-	-	-	9
1970 ³	-	-	-	1	-	3	1	-	-	-	8	13
TOTAL	6	1	0	3	1	17	2	2	0	0	10	42

¹Forest Service national research accomplishment reports were used as the basis for listing. Categorization of subject matter was accomplished by CNA, using report titles, and abstracts where available. It was possible for one article to be categorized in more than one subject area.

²No abstracts were provided in these annual reports. A greater degree of speculation was required to categorize articles by the title only.

³Not all articles were abstracted in these annual reports. A greater degree of speculation was required to categorize articles without abstracts.

TABLE A-25. Rights-of-way (ROW) acreage by type and region in the United States (Source: USDA-States-EPA 2,4,5-T RPAR Assessment Team, 1979).

ROW type	Assumed ROW width (feet)	Eastern Region	Central Plains & Rocky Mountain Region	West Coast Region	Alaska & Hawaii	Total U. S.
RAILROAD						
Total ROW	100 ^{a/}	1,505,442	721,030	182,509	8,121	2,417,102
Brush control area (excludes road bed)	80 ^{b/}	1,204,354	576,824	146,007	6,497	1,933,682
HIGHWAYS-RURAL ^{c/}						
Interstate:						
Total ROW	300	663,345	442,145	91,091	545	1,197,127
Vegetation area	220 ^{d/}	486,453	324,240	66,800	400	877,893
Primary						
Total ROW	75	2,022,772	1,339,028	332,046	38,272	3,732,118
Vegetation area	27 ^{e/}	723,198	482,050	119,536	13,778	1,343,562
Secondary						
Total ROW	50	9,255,430	5,883,903	1,580,818	40,885	16,761,036
Vegetation area	18 ^{f/}	3,331,955	2,118,205	569,095	14,719	6,033,973
Total highway ROW		11,941,547	7,665,076	2,003,955	79,702	21,690,280
Total highway vegetation area		4,546,606	2,924,495	755,431	23,897	8,255,428
PIPELINES	509 [/]	804,618	1,346,206	36,061	988	2,187,873
ELECTRIC TRANSMISSION ^{h/,i/}						
REA, public utilities and Federal projects	100 ^{j/}	604,897	600,763	232,654	9,055	1,447,368
Private utilities ^{k/}						
31 KV	40	26,773	9,076	693	412	36,955
31-50 KV	50	289,576	102,491	2,424	3,394	397,885
51-131 KV	75	726,264	326,027	204,382	2,800	1,259,473
132-188 KV	110	504,800	234,067	12,053	1,560	752,480
189-253 KV	125	278,909	86,348	122,061	-	487,318
254-400 KV	150	224,909	107,727	-	-	332,636
401-600 KV	180	101,869	40,254	51,120	-	193,244
601-850 KV	225	38,591	-	7,909	-	46,500
Total Electric ROW		2,796,588	1,506,753	633,296	17,221	4,953,858

TABLE A-25, cont.

	Eastern Region	Central Plains & Rocky Mountain Region	West Coast Region	Alaska & Hawaii	Total U. S.
OVERALL SUMMARY					
Total ROW acres	17,048,195	11,239,065	2,855,821	106,032	31,249,113
Percent of ROW in U.S.	55%	36%	9%	1%	
Total vegetation acres	9,352,166	6,354,278	1,570,795	53,603	17,330,842

a/ROW width based on discussions with railroad weed control contractors.

b/Excludes 20 feet for road bed which is generally treated with soil sterilants rather than 2,4,5-T.

c/ROW widths based on discussions with highway department officials in Indiana and Maryland, and Federal Highway Administration.

d/Excludes two lanes, each consisting of 24' road, 12' and 4' shoulders or 40' per lane of divided highway.

e/Excludes a 24' road and two 12' shoulders.

f/Excludes a 24' road and two 4' shoulders.

g/Source: 1975. U. S. Dept. Interior. The need for a national system of transportation and utility corridors. Table VIII-2.

h/Only mileage designated as transmission considered. Assumes most distribution mileage occurs in populated areas or often on shared ROW with others such as rural roads; or generally of such low voltage that only narrow ROW required which tends to be trimmed rather than treated with herbicide. This eliminates 1.7 million miles of REA distribution lines.

i/Transmission miles or structure miles = circuit miles x 0.85. This ratio derived from comparison of circuit miles and structure miles of private utility lines greater than 132 KV.

j/ROW width suggested as average width for REA by REA officials.

k/ROW widths are assumptions made after discussions with electric utility and other knowledgeable personnel.